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DYNAMO-ELECTRIC MACHINES.

ELECTRIC light engineers are again indebted to Prof. Silvanus Thompson for much original and valuable information concerning the construction and performance of dynamos of various types.

His latest paper on "Recent Progress in Dynamo-Electric Machines," the most interesting portion of which we publish this week, is a most valuable contribution, and contains much to cause surprise. Indeed he opens up a wide field for a discussion, which could be made of great benefit to all if carried on in a spirited way. It will, doubtless, be a source of wonderment to many engineers that the machine of M. Gramme, instead of being superior to that of Pacinotti, is, according to Prof. Thompson's experiments, considerably its inferior, and shows a retrograde movement rather than an advance in dynamo machines. In the face of the many practical tests which have been made with the Gramme machines, in comparison with other forms in which the Pacinotti armature has been adopted, it is by no means clear that Prof. Thompson has established by his tests any real proof of what he conveys by his lecture.

If the Gramme dynamo is inferior to those of the Pacinotti type, we are afraid that the Siemens, Edison, Heinrichs, Ball, and others must be included in the Gramme category; yet actual figures seem to show that most of these machines can hold their own with the Weston, Lumley, or others affecting the Pacinotti armature.

It would be interesting to ascertain whether a greater force had to be exerted in turning the Pacinotti ring in the Professor's experimental apparatus than was the case when the Gramme armature was used.

We should imagine that such would be the case, but even were it not so it does not appear so very evident that the greater throw of the galvanometer-needle was due to any higher efficiency in the Pacinotti construction of machine. The question raised, however, by these experiments is of such an interesting nature that we feel sure many electricians will not rest satisfied until they have repeated Prof. Thompson's tests. It may be that they will be generally verified, or perhaps it will be found that through some errors of observations, or want of similarity of conditions under which the experiments were made, the results given in the Professor's paper may require modification. We think that a falling weight, or a spring, would have been far preferable to the jerking lever employed for moving the armature in the experimental apparatus.

A very interesting portion of the lecture is that devoted to the peculiarities of the Schuckert machine, and to the improvements effected therein by Mr. Mordey, of the Anglo-American Brush Electric Light Corporation.

This gentleman has worked quietly and perseveringly, and his reward has been the production of a machine which, for incandescent electric lighting, appears to be equal, if not superior, to the best dynamos hitherto produced. One feels curious to know whether the engineers of the Pilsen-Joel and General Electric Light Company have found the same faults existing in the Schuckert machines as those described by Mr. Mordey, and, if so, what steps have been taken for their avoidance.

The shape and dimensions of the pole-pieces of the field-magnets of dynamos play such an important part in their performance that much more attention must be devoted for the future to these portions of the machines. Dr. Hopkinson's improvements on the Edison apparatus is an example of what may be accomplished by means of a due appreciation of such details.

Prof. Thompson, during his discourse, alluded to the labours of M. Marcel Deprez, and we also would bring before the notice of our readers the valuable article from the pen of the French electrician now appearing in our columns. This will be found by far the most instructive and exhaustive paper on the electrical transmission of energy which has yet been forthcoming.

TESTS OF ELECTRIC LIGHT SYSTEMS.

(*Continued from page* 199.)

In the measurements of electromotive force, Thomson's potential galvanometer, by White, was used. In the beginning a large number of comparison observations were made, in which the same electromotive force was measured by this instrument and by the well-known method of discharging a condenser through a high-resistance galvanometer.

A condenser of one-half micro-farad capacity, and a reflecting galvanometer of nearly 7,000 ohms resistance, both by Elliot Brothers, were used with a battery of 10 Daniell cells in good condition. These comparisons proved that the indications of the potential galvanometer could be relied upon as trustworthy within practical limits, and in the actual tests it alone was used on account of the greater convenience and rapidity with which observations could be made. Further tests of its accuracy were made, however, which will be referred to later. It is sufficient to say that this instrument, in form and construction, is quite similar to the current galvanometer already described, except that the coil has a resistance of nearly 7,000 ohms. A key is placed in the circuit, so that the current passes through the coil only during the few moments necessary to secure a reading, thus preventing the heating of the coil. The difference of potential in volts between the two points to which the leading wires are connected, is found by the same process as is used for reducing the readings of the current galvanometer to ampères. In measuring the efficiency of the dynamos, wires were brought from their binding-posts to the galvanometer. In the arc light machines the electromotive force was high, amounting to more than 1,200 volts in the Thomson-Houston dynamo, and it was, therefore, desirable to introduce extra resistance in the galvanometer circuit. From resistance-boxes made by Elliot Brothers an amount equal to 17 times the resistance of the galvanometer was thrown in, thus bringing

the fall in potential in the galvanometer within easy range. Great care was taken to see that the coils were not heated during these measurements, and for this purpose the boxes were opened, and the coils exposed to the air, frequent examination being made to see that no rise in temperature took place. Precisely the same arrangement existed throughout the tests of both arc systems. During the photometric tests the wires of the potential galvanometer were attached directly to the lamp under test, so that the fall in potential through the lamp only was measured.

Photometric Measurements.

Unquestionably the most difficult question to deal with in work of this kind is the question of photometry. The expression of illuminating power in "candles" is a matter of great uncertainty, arising from the uncertain character of the standard, and also from the great inequality existing in the intensity and composition of the lights which are brought into comparison. As the test was intended to be purely competitive, the jury decided to ignore the question of "candle-power" entirely, and confine itself to a comparison of the lights under consideration. It is believed that the adoption of this plan rendered the results free from many errors to which they would otherwise have been liable.

The photometric comparisons were made by means of the ordinary Bunsen disc photometer, as modified by Letheby. Some preliminary experiments were made with one of Glan's spectrum photometers, for the use of which the jury was again indebted to the kindness of Prof. Brackett. The adjustments of this instrument are delicate, and observations cannot be made so rapidly with it as with the ordinary disc photometer; so that, in consideration of the limited time at the disposal of the jury, it was decided not to attempt its general use throughout the tests. It was hoped and intended, in the beginning, to make a thorough examination of the composition of the different lights, but unforeseen delays in the preparation of other portions of the machinery of the test forbade this. As the candle was not made use of, all the lights which were compared were more nearly of the same composition, and thus much of the difficulty in the use of the disc photometer did not appear.

It was found most convenient to make the comparison of the arc lights through one of the incandescent lamps, as the steadiness and constancy of these could be depended upon during the time necessary for a comparison. In these measurements a long gallery in the basement of the main building, and adjoining the testing-room, made it possible to place the two lights which were being compared at a distance of 50 feet from each other. The line extended into the testing-room, where the photometer-bar 10 feet in length, was placed. An Edison incandescent lamp, nominally of 16 candle power, was used as a standard. In the first series of experiments comparisons were made with the arc lamps in three different positions, five readings of the position of the photometer-box and of the galvanometers being made at each position. The lamp was first suspended in its normal vertical position, then afterwards it was inclined at an angle of 45 degrees, first with its base away from the photometer-box, and afterwards with its base towards the same. After such a series had been completed with one of the two lamps in competition it was at once removed, and its place was supplied by the other. On the following night the comparison was continued, other lamps having been selected; but the lamps were tested in only two positions—the normal position, and that in which the base of the lamp was towards the photometer-box; these being regarded as the positions of the greatest importance. Altogether, twenty-five photometric observations were made in comparing the arc-lamps. The lamps compared were taken at random from those in use by the exhibitors.

The comparison of incandescent lamps presents questions of far greater delicacy and difficulty. There is one element, in the economy of an incandescent lamp, which does not enter to any extent in the consideration of arc-lamps; that is, the life of the lamp. Although of great importance, it did not seem possible, in the limited time which was at the disposal of the jury, to investigate this point. The only fair and impartial method of making such an investigation involved, in the opinion of the jury, the continuous and prolonged burning of a large number of lamps belonging to the different competing systems. Under the circumstances it was absolutely impossible to make use of this method.

There exists also difference of opinion as to the proper method of comparing the efficiency of two incandescent lamps. They may be reduced to the same illuminating power, and the electrical energy consumed by each may be compared; they may be brought to a condition in which they consume the same electrical energy, and their illuminating power compared; or they may be allowed to differ in both of these elements, and comparisons be made in both.

The first method has been pursued in several tests which have been made both in Europe and in this country.

Incandescent lamps are generally made to be equal, nominally, to a given number of standard candles; but by modifying the consumption of energy, a lamp of nominally low candle power can be made to produce almost any degree of illumination, from nothing up to the equivalent of several hundred candles, the high illumination being, of course, at the expense of the life of the lamp. If this element is left out of consideration, the efficiency of a lamp increases rapidly with its degree of incandescence. As it is by no means necessary that incandescent lamps should run at a fixed "candle-power," it will follow that the temperature at which a lamp will show greatest efficiency (including the life element) will depend greatly upon its construction.

Taking two lamps of radically different construction, however, there will be for each a certain set of conditions as to current strength and electromotive force, and including the element of life, under which it would show the highest efficiency and economy. After such conditions were determined for each lamp, a strict comparison would be possible. The reduction of two such lamps to the same degree of illumination would probably be unfair to one or the other, or possibly to both, if the element of life is not considered.

Suppose that a lamp in one system is at its best, *all things considered*, at 15-candle power, and that one in another reaches its highest degree of efficiency at 16-candle power. If they are both brought to 15-candle power, the second must suffer in the comparison; and if both are brought to 16-candle power, *and the element of life is not considered*, it will again suffer, for the apparent efficiency of the first will be increased by its higher incandescence.

As the labour of determining the most favourable conditions for each lamp would be so great as to necessarily throw that method out of consideration, the jury felt constrained to adopt the last of the three methods mentioned above. The jury assumed, in fact, that the exhibitors of the different systems had already determined these favourable conditions in their own interest; and that in putting their lamps before the public for the entire period of the exhibition, each maintaining more than two hundred lamps in different parts of the exhibition building, they would operate them as nearly as possible in accordance therewith. In other words, it was decided to compare the lamps as they were used in the exhibit, determining the ratio of their illuminating power, and measuring the electrical energy consumed by each. It is proper to state that the lamps of both systems were spoken of by their respective representatives as 16-candle power lamps, although certain marks on the lamps which were supposed by the jury to refer to candle-power did not exactly agree.

To secure impartiality of selection, the jury requested permission to have access to the supply of lamps kept by each company for use in the exhibit, which permis-

sion was freely granted. From each, ten or twelve were selected at random, and carried to the testing-room; and from these the lamps which were compared were taken. They were placed upon the photometer-bar at a distance of 125 inches from each other, and a system of switches was arranged, so that the galvanometers could be quickly connected with one or the other. Measures of current and electromotive force were made rapidly and continuously during the photometric comparison.

Neither of the two lamps under test illuminated equally in all directions. They were therefore compared in nine different positions, each lamp assuming three, which were designated respectively, "flat," "edgewise," and "45 degrees;" and each position of one was compared with all of the other. Five sets of readings were made at each position, making, in all, 45 comparisons of the two lamps. A number of preliminary comparisons were made, which were not considered as forming a part of the actual test. The latter was made on the evening of September 29th.

The determination of the efficiency of the dynamos consisted in measuring the power consumed, as shown by the dynamometer, on the cradle of which the dynamo was placed, and at the same time measuring the current, and the electromotive force at the binding-screws of the machine. The speed of the main shaft being nearly uniform, it was necessary to place different pulleys upon it, in order to secure the necessary speed for the armatures of the different machines. The speed of running being a matter which concerned the exhibitors rather than the jury, they were requested to furnish the dimensions of these pulleys, and accordingly did so. The average speed of the armature of the Weston dynamo for incandescent lamps was a little above 1,030 revolutions per minute, during three different series of observations made while the machine was on the cradle. The Edison dynamo was placed on the cradle on the afternoon of October 2nd, when a series of measurements was made with an average speed of 1,068 revolutions. This was above what may be called the "normal speed," which was due partly to the size of the pulley, and partly to the fact that the engine was doing but little other work, and was probably running a little above its normal rate. In the evening the tests were continued, the speed of the armature being a little below a thousand revolutions, the electromotive force being also less. It will be observed that the "efficiency" of this dynamo, under the latter conditions, differs from that under the former by only two-tenths of one per cent. Particular attention is called to the fact, that no photometric measurements were made with lamps on the circuit of the Edison machine, which was on the dynamometer; those used being supplied from another similar dynamo, which was run by an Armington and Sims engine, which formed a part of the Edison exhibit. A glance at the results given below will show that the electromotive force in the latter case was much lower than in the former.

Tests of the galvanometers.

Although the jury was satisfied of the accuracy of the Thomson galvanometers, within all practical limits, before deciding to rely upon their indications, for reasons that need not be referred to here, it was considered desirable, after the conclusion of the tests, to make such an examination of them as would leave no doubt as to the correctness of this opinion. The chief cause of error in these instruments, and in all of a similar construction, is the possible variation in the strength of the permanent magnets which establish the field in which the needles move. The existence of a strong field is a great advantage, as has already been pointed out, provided its value is known. An examination of the instruments was made before they were taken to Cincinatti; and then, again, when they were mounted in the testing-room, they were compared with others not liable to such alterations as before related. Numerous tests were made to ascertain if each instrument was consistent with itself by measuring the same quantity with the magnetometer at different points of the scale, thus varying the position of the needle; and the results were satisfactory. Finally, after the instruments were returned to the physical laboratory of the Ohio State University, they were subjected to tests, a brief account of which is as follows:—

For the potential galvanometer, ten cells of the "gravity battery"—the elements of which were zinc, zinc sulphate, copper sulphate, and copper—in good condition, were individually compared by the condenser method with a standard Daniell cell set up for the purpose. They differed very little among themselves; and when the electromotive force of the ten, in series, was measured by means of the Thomson instrument, the resulting electromotive force of the Daniell was 1·106 volts. The instrument was also compared with one of Ayrton and Perry's voltmeters, kindly furnished for the purpose by the Electric Supply Company of New York City. For this purpose recourse was had to an Edison lighting plant, the instruments being applied to the same lamp. The fall in potential in the lamp was at first 110 volts, which was beyond the range of the Ayrton and Perry instrument; but it was reduced a little below 100 volts, and two measurements were taken with each instrument.

The Thomson read the same in both measurements, making the electromotive force 97·6 volts. The divisions on the scale of the Ayrton and Perry were extremely small, making the reading very difficult. From it were obtained, in the two measurements, 96·1 and 95·5 volts.

Assuming that the field of the potential galvanometer is known, it is easy to determine that of the current galvanometer, as the magnets are interchangeable. A series of observations was made in which a practically constant quantity was measured, first with one of these magnets on the magnetometer, and then with the other, alternating throughout the series. Twelve observations made in this way show a mean difference of 1·75 per cent. between the two magnetic fields. In the numbers used in these tests the difference is 2 per cent.

The current galvanometer was also compared with an Ayrton and Perry ammeter at the same time at which the potential instruments were compared. The circumstances did not allow the use of a stronger current than that passing through a single Edison lamp. The result was therefore not of great value. The Thomson showed 1·05 ampères, and the Ayrton and Perry gave 1·03 for the same current.

Several tests of the current galvanometer were made by means of a battery of five Grove cells, which were freshly set up. The reading of the galvanometer was noted, and then a resistance of one ohm was introduced into the circuit. The first reading was 19, and the second was 9·5; showing that the resistance of the battery and galvanometer was one ohm. The electromotive force of the battery was then determined by means of the potential galvanometer. Two measurements were made; the first giving 9·43 volts, and the second 9·56 volts. Assuming the resistance to be one ohm, as shown above, these numbers would represent, in accordance with Ohm's law, the current in ampères. The current, as calculated from the galvanometer reading, was 9·5 ampères.

Many other tests of a similar character were made, all of which showed that the galvanometers must be admitted to be what they were assumed to be during the tests—practically correct. But, even if they were somewhat in error, the similarity of conditions under which the competing systems were tested was such that all would be affected alike.

Results.

In determining the efficiency of the dynamos, after everything was found to be in good order, a run of about half-an-hour was made; during which time readings were taken every two minutes, as nearly as could be, of the dynamometers and electrical instruments. Generally from ten to twenty sets of readings were secured. In most cases two or more "runs"

were made; the repetition being in some instances the desire of the jury, and in others of the exhibitors. Sometimes the conditions under which the dynamo was running were changed by the exhibitors, with the expectation, doubtless, of increasing its efficiency thereby. In the following summary of results, the numbers showing the electromotive force, current strength, power consumed, &c., are the means of a number of observations.

Photometry of arc-lamps.

The table given below shows the results of the photometric comparison of the two arc-lamps, and will be easily understood. The arrows show the direction of the light measured in each series: thus, ← means a horizontal measurement; ↖ means that the measurement was of the light going upward at an angle of 45°; and ↙ refers to the light going downward at an angle of 45°. For convenience, the intensity in terms of the standard (an Edison incandescent lamp) is multiplied by 1,000 before dividing by the number of Watts.

It will be seen that the different lamps differed from each other considerably in their efficiency. This was especially true of the Weston lamp, which was irregular in its action. The numbers under the head of "General means" show the average light in terms of the standard, in all directions measured, and the relative illuminating-power per unit of energy. There is a difference of more than 40 per cent. in favour of the Thomson-Houston.

EFFICIENCY OF DYNAMOS.

	Thomson-Houston dynamo for arc lighting.		Weston dynamo for arc lighting.	Weston dynamo for incandescent lighting.			Edison dynamo for incandescent lighting.	
	Sept. 25.	Sept. 26.	Sept. 28	Sept. 29.			Oct. 2.	
Electromotive force, in volts	1232·0	1175·0	626·0	69·2	60·0	65·0	124·9	122·8
Current in ampères	10·03	10·08	20·3	168·1	145·7	157·4	124·7	119·3
Electrical horse-power	16·6	15·9	17·0	15·6	11·7	13·7	20·9	19·6
Horse-power consumed	19·32	20·59	19·75	18·55	12·8	15·5	21·96	20·64
Percentage of efficiency	85·9	77·2	86·5	84·1	91·4	88·4	95·2	95·0

ARC LAMPS.

THOMSON-HOUSTON.						WESTON.					
Direction of light.	Current.	Electromotive force.	Watts.	Intensity in terms of standard.	$\frac{1000\ I}{W}$	Direction of light.	Current.	Electromotive force.	Watts.	Intensity in terms of standard.	$\frac{1000\ I}{W}$
←	10·2	45·9	467	16·2	34·7	←	20·7	23·9	495	25·9	52·4
↖	10·2	46·7	475	13·2	27·8	↖	20·1	23·3	469	17·6	37·4
↙	10·2	46·3	471	85·0	180·3	↙	19·8	21·9	435	32·3	74·4
OTHER LAMPS.											
↑	10·1	46·1	465	18·0	38·8	←	20·0	25·6	512	30·7	59·9
↙	10·2	46·3	474	98·8	209·0	↙	20·8	25·0	522	51·7	99·2
MEANS.											
←	–	–	–	17·1	36·7	←	–	–	–	28·3	56·1
↖	–	–	–	13·2	27·8	↖	–	–	–	17·6	37·4
↙	–	–	–	91·9	194·6	↙	–	–	–	42·0	86·8
GENERAL MEANS.											
		–	–	40·7	86·4		–	–	–	29·3	60·1

Photometry of incandescent lamps.

The table below, showing the results of the photometric comparison of the incandescent lamps, will need but little explanation. In the first column the relative position of the carbon filaments is shown: thus, | | means that they were parallel to each other, and at right angles to the photometer-bar. The three positions of a lamp were designated as "flat" (|), "edge-wise" (—), and "45 degrees" (\ or /). $\frac{W_E}{W_M}$ denotes the Watts of the Edison divided by the Watts of the Maxim. The column headed $\frac{E}{M}$ shows the actual illuminating power of the Edison, compared with the

INCANDESCENT LAMPS.

POSITION.		EDISON.			MAXIM.			$\frac{W_E}{W_M}$	$\frac{E}{M}$	$\frac{E_E}{M_E}$
Edison.	Maxim.	Current.	Electrom. force.	Watts.	Current.	Electrom. force.	Watts.			
|	|	·648	113·0	73·2	·887	63·7	56·5	1·30	1·11	·855
/	|	·639	114·7	72·5	·887	64·5	57·2	1·26	1·13	·891
—	|	·636	114·6	72·9	·870	61·8	53·7	1·36	1·28	·941
—	/	·622	115·4	71·8	·853	62·2	53·0	1·35	1·65	1·22
—	—	·631	115·4	72·8	·853	61·4	52·3	1·39	4·58	3·29
/	—	·631	116·1	73·3	·887	63·0	55·8	1·31	3·96	3·02
—	—	·631	115·7	73·0	·870	62·6	54·4	1·34	3·74	2·79
—	/	·639	116·5	74·5	·887	63·0	55·8	1·33	1·35	1·02
/	/	·648	114·7	73·5	·853	62·6	53·4	1·38	1·66	1·21

Maxim as a unit; and the numbers are the squares of the ratios of their respective distances from the photometer-box. The numbers in this column, divided by those in the one preceding, give the numbers in the last column, headed $\frac{E_E}{M_E}$, or the light from the Edison per unit of energy as compared with the Maxim.

The results of these comparisons in nine different positions make it possible to establish certain comparison equations, from which means may be obtained which will serve to eliminate, to some extent, the errors of experiment.

Let a = the light from the Maxim lamp "edgewise;" then, by working through the different positions of the Edison, the above results give—

Maxim	—	a	a	a
	⟋	$2{\cdot}77a$	$2{\cdot}39a$	$2{\cdot}77a$
	|	$3{\cdot}58a$	$3{\cdot}50a$	$3{\cdot}37a$

and for means—

Maxim	—	a
	⟋	$2{\cdot}64a$
	|	$3{\cdot}48a$

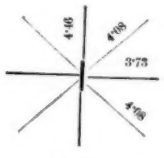
By a similar computation it is found that—

Edison	—	$4{\cdot}58a$	$4{\cdot}45a$	$4{\cdot}36a$
	⟋	$3{\cdot}96a$	$3{\cdot}93a$	$4{\cdot}38a$
	|	$3{\cdot}74a$	$3{\cdot}58a$	$3{\cdot}86a$

the means of which give—

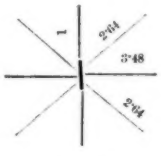
Edison	—	$4{\cdot}46a$
	⟋	$4{\cdot}08a$
	|	$3{\cdot}73a$

FIG. 1.



EDISON.

FIG. 2.



MAXIM.

Figs. 1 and 2 show the arrangement of these intensities of illumination around the carbon filament, the plane of the filament being vertical, and the Maxim edgewise being taken as unity.

For the mean all round, the result is—

$$\text{Edison} = 4{\cdot}09 \qquad \text{Maxim} = 2{\cdot}44.$$

$$\frac{4{\cdot}09}{2{\cdot}44} = 1{\cdot}676 = \frac{E}{M} \text{ in light.}$$

But from the previous table,

$$1{\cdot}336 = \frac{E}{M} \text{ in energy:}$$

therefore $\frac{1{\cdot}676}{1{\cdot}336} = 1{\cdot}25 = \frac{E}{M}$ *in light per electrical horse-power.*

It seems evident that this difference of 25 per cent. in favour of the Edison lamp is largely due to the form of the incandescent filament as compared with that of the Maxim lamp. The latter shows great inequality in illumination in different directions, the light measured from the flat side being about 3½ times as great as that obtained when the lamp is edgewise. The effect of this increased radiating surface is shown in the last column of the above table, from which it appears that in the comparison of the Maxim "flat" with the Edison in all positions, the former shows a higher actual efficiency than the latter. If this large radiating surface could be made to distribute its effect around the circumference, the lamp would, in the opinion of many, be greatly improved. It is fair to say, however, that the unequal distribution of light is claimed, by at least some of the representatives of this lamp, to be an important advantage. It was not so considered by the jury.

The form of the carbon filament in the Edison lamp is such that a much greater uniformity of illumination results. While the Maxim form has the advantage of concentrating the radiating surface, the arrangement of the carbon to accomplish this greatly diminishes its effectiveness in the "edgewise" position. In the Edison there is but a single loop; and, furthermore, this is generally curved, so that it does not lie in one plane. As a result, one side of the loop never exactly hides the other, and there is but little loss from that source. It will be seen in the above figure that the illuminating power of the lamp edgewise actually exceeded that in any other direction. This difference was too constant and too great to be attributed to error in experiment. It is attributable, no doubt, to the fact that in this position the luminous lines lie nearly in the axis of the pear-shaped glass containing them, as viewed from the photometer-box; there being, therefore, less scattering of the light in transmission, and possibly some gain on account of reflection. Of course if a lamp were used in which one of the branches of the loop exactly or nearly covered the other in this position, a different ratio of illumination might follow.

Throughout the entire series of tests the jury was fortunate in having the assistance of Mr. A. L. Rohrer, a student in physics in the Ohio State University.

In the distribution of work Mr. Eddy and Mr. Laidlaw made the observations, and kept the records of the dynamometer work; Mr. Laidlaw also taking and reducing the indicator cards. Mr. French made the readings of the position of the photometer-box, and set the same. Mr. Mendenhall generally read one of the galvanometers, and Mr. Rohrer the other, the latter generally keeping the notes of the electrical work, although this was done on several occasions by Mr. French and by Mr. Laidlaw.

The results of these tests seem to point to one conclusion of very considerable interest. It happened that the competition in both the arc and incandescent systems was between low electromotive force and great strength of current on the one hand, and high electromotive force, with weaker current, on the other. In one arc system the electromotive force was almost exactly double, and the current almost exactly half, that of the other. In the incandescent systems the contrast, although not so great, was very marked. In these trials the advantage was decidedly on the side of high electromotive force.

RECENT PROGRESS IN DYNAMO-ELECTRIC MACHINES.*

By Prof. SILVANUS P. THOMPSON.

FIFTEEN months ago, I had the honour of delivering in this place a course of three Cantor Lectures on "Dynamo-electric Machinery." In the first of those lectures, the endeavour was made to trace out a physical theory of the action of dynamos, and to follow the theory into its bearings upon the construction of such machines. In the second lecture, a large number of actual machines were considered and compared with one another and with the theory; and in the third lecture, the dynamo was considered in its functions as a mechanical motor.

As the present paper may be considered supplementary to the Cantor Lectures, it will be convenient to treat of the features of progress which come to night under review in a similar order of topics. I, therefore, take up first the theory of the dynamo.

There are, in fact, three distinct theories of the dynamo: (1) a physical theory, dealing with the lines of magnetic force and lines of current in which these quantities are made, without further inquiry into their why or how—the basis of the arguments; (2) an algebraical theory, founded upon the mathematical laws of electric induction and of theoretical mechanics; and (3) a graphical theory, based upon the possibility of representing the action of a dynamo by a so-called "characteristic" curve in the manner originally devised by Dr. Hopkinson, and subsequently developed by Frölich, Deprez, and others. The last of these three methods, though it has not received any great or striking development during the past year, has proved itself to be the most invaluable aid in the practical construction of dynamo machines. One has only to refer to the use made of characteristics by Mr. Kapp, in his articles on the winding of "compound" dynamos, and, still more recently by Dr. Hopkinson, in solving

* Paper read before the Society of Arts, Feb. 28th, 1884.

certain problems in the electrical transmission of energy, to see how invaluable the method is.

In the algebraic theory much progress has been made during the past year; and there certainly was room for it. Monsieur Joubert has published, in the *Journal de Physique* for July, 1883, a long mathematical article, the object of which is to deduce the equations of the dynamo, taking into account not only the action of self-induction in the circuit, but also some of the terms of the second order usually neglected in first approximations. It is a question whether he has not still omitted some terms of quite as great an importance as those retained in the complicated formula deduced by him. But the matter can hardly be discussed in the present paper. Still more recently, Professor Clausius has published in Wiedemann's *Annalen*, for November last, a paper expounding a mathematical theory of dynamo-electric machines far more comprehensive, and, I venture to say, far more true, than any other yet put forward. Without shirking any of the mathematical difficulties presented by the complications of mutual induction between, and self-induction in, the various organs of the machine, and by the admitted incompleteness of all our formula for connecting the magnetism of an electro-magnet with the strength of its exciting current, Professor Clausius has succeeded in putting the equations into a shape, not only far more satisfactorily from the point of view of completeness, but in framing those equations in a manner that must commend itself to every engineer. The relative simplicity attained by Clausius is, in fact, due to his lavish introduction of a set of arbitrary constants, each one of which having values that must be determined by experiment, for each machine or type of machines. The number of new symbols thus introduced is considerable; and it would be very desirable to find names for the separate constants to be determined. It cannot be said even yet that the mathematical theory of the dynamo is near completion. A further paper by Professor Clausius is promised; and it remains to be seen whether this article will deal with some of those points in which the graphic method has been so useful in practice, for example, in determining the proper quantities of wire for the coils in "self-regulating" or "compound" machines, and in finding the best shape to give to magnets and pole-pieces.

Turning to the physical theory of the dynamo, there is much to record. Our knowledge of the inductive actions which go on between the field-magnets and armatures of dynamos, has received considerable additions during the past year from the researches of Isenbeck, Cunynghame, Pfaundler, and others. There is a good deal to be said on this head, and I have several new results to announce as the result of my own observations. Let me take as my starting point a matter mentioned in my Cantor Lectures, namely, the distribution of potential round the collector or commutator of a dynamo. Mr. W. M. Mordey, who first drew my attention to the fact that this distribution was irregular in badly designed machines, had devised the following method of observing it. One terminal of a voltmeter was connected to one of the brushes of the dynamo, and the other terminal was joined by a wire to a small metallic brush or spring, which could be pressed against the rotating collector at any desired part of its circumference. I then made the suggestion that these indications might with advantage be plotted out round a circle corresponding to the circumference of the collector. Figs. 1 and 2, which are reproduced from my Cantor Lectures, serve to show how the potential in a good Gramme machine rises gradually from its lowest to its highest value. The same values

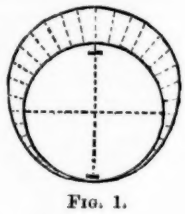


FIG. 1.

as are plotted round the circle in fig. 1 are plotted out as vertical ordinates upon the level line in fig. 2. I made the remark at the time that if the magnetic field in which the armature rotated were uniform, this curve would be a true "sinusoid," or curve of sines; and that the steepness of the slope of the curve at different points would enable us to judge of the relative idleness or activity

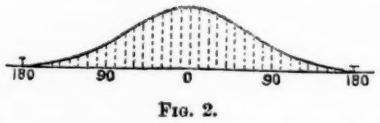


FIG. 2.

of coils in different parts of the field. About the same time, I developed this method of observation a little further, and used two small metal brushes, at a distance apart equal to the width between the middle of two consecutive bars of the collector of my little Siemens dynamo for the same purpose.* As the collector rotated, these two little brushes (see fig. 3) gave on the voltmeter an indication which measured exactly the activity of the induction, in that section of the armature which was passing through the particular position in the field corresponding to the position of the contacts. I found, in the case of my Siemens dynamo, that the result was fairly satisfactory, for the difference of potential indicated was almost *nil* at the sections close to the proper brushes of the machine, and was a maximum about half way between. In fact, the differences of potentials was rising most markedly at 90° from the usual brushes, or precisely in the region where (as seen in fig. 2) the slope of the curve of total potential was greatest. One immediate result of Mr. Mordey's observations on the distribution of potential, and of my method of mapping it, may be recorded. I pointed out to Mr. Mordey that in a dynamo where the distribution was faulty, and where the curves of total potential showed irregularities, the fault was due to irregularities in the induction at different parts

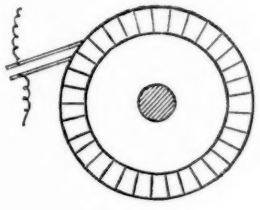


FIG. 3

of the field; and that the remedy must be sought in changing the distribution of the lines of force in the field by altering the shape of the pole pieces. I am able now, after the lapse of fifteen months, to congratulate Mr. Mordey on the entire and complete success with which he has followed out these suggestions. He has entirely cured the Schuckert machine of its vice of sparking. The typical bad diagram given in my Cantor Lectures was taken from a Schuckert machine before it received from his hands the modifications which are so signally successful to-day.

Since the experiments above detailed, I have experimented on my Siemens dynamo in another way. The machine was dismounted, and its field magnets separately excited. Two consecutive bars of the collector were then connected with a reflecting galvanometer having a moderately heavy and slow moving needle. A small lever clamped to the collector allowed the armature to be rotated by hand, through successive angles equal to 10°, there being thirty-six bars to the collector. The deflexions obtained of course measured the intensity of the inductive effect at each position. The result confirmed those obtained by the method of the two wire-brushes.

I mention these methods, which have been used in my laboratory at Bristol, and have not been published before, because they relate strictly to the physical theory of the dynamo as developed in my Cantor Lectures, and also because of their practical application to all dynamos in which any such defect appears. They are also very closely related to the researches of Dr. Isenbeck, which next claim attention.

Dr. Isenbeck described, in the *Electrotechnische Zeitschrift* for last August, a beautiful little apparatus for investigating the induction in the coils of a Gramme ring, and for investigating the influence exerted by pole pieces of different form upon these actions.

Isenbeck's apparatus consists of a circular frame of wood placed

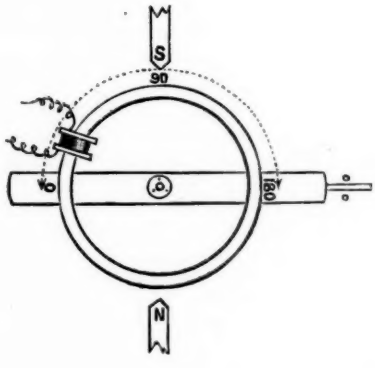


FIG. 4.

between the poles of two small bar-magnets of steel, each 25 centimetres long, lying 25 centimetres apart. On the frame, which is pivotted at the centre, is carried a ring of wood or iron, upon which is placed at one point a small coil of fine wire. This corresponds to a single section of the coils of a Pacinotti or of a Gramme ring, of which the ring of wood or iron constitutes the core. The coil can be adjusted to any desired position on the

* Dr. Isenbeck has also independently used a similar arrangement to investigate the induction going on in a Gramme dynamo.

ring, and the ends communicate with a galvanometer. On vibrating it isochronously with the swing of a needle of the galvanometer, the latter is set in motion by the induced currents, and the deflexion which results shows the relative amount of induction going on in the particular part of the field where the coil is situated. The vibrations of the frame are limited by stops to an angle of 7° 5′. Pole-pieces of soft-iron, bent into arcs of about 160° so as to embrace the ring on both sides, but not quite meeting, were constructed to fit upon the poles of the magnets. In some of the experiments a disc of iron was placed internally within the ring; and in some other experiments a magnet was placed inside the ring, with its poles set, so as either to reinforce, or to oppose, the action of the two external poles. In Dr. Isenbeck's hands this apparatus yielded some remarkable results. Using a wooden ring, and poles destitute of polar expansions, he observed a very remarkable inversion in the inductive action to take place at about 25° from the position nearest the poles.

Fig. 4 is a sketch of the main parts of Isenbeck's instrument, and shows the small coil mounted on the wooden ring, and capable

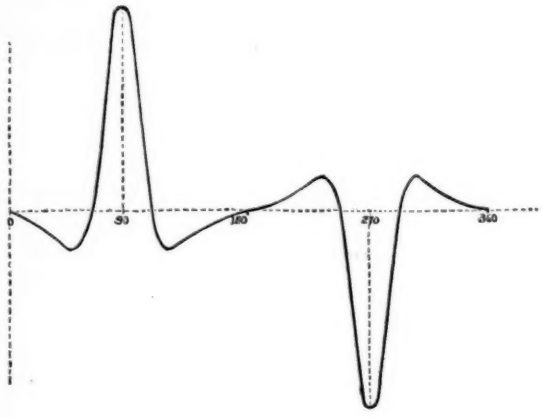


FIG. 5.

of being vibrated to and fro between-stops. When vibrated at 0°, or in a position on the diametral line at right angles to the polar diameter, there is no induction in the coil; but as the coil is moved into successive positions round the ring towards the poles, and vibrated there, the induction is observed first to increase, then die away, then begin again in a very powerful way, as it nears the pole, where the rate of cutting the lines of force is a maximum. This powerful induction near the poles is, however, confined to the narrow region within about 12° on each side of the pole. It is beyond these points that the false inductions occur, giving rise in the coil, as it passes through the regions beyond the 12°, to electromotive forces opposing those which are generated in the regions which are close to the poles.

These inverse inductions were found by Isenbeck to be even worse when an iron disc, or an internal opposing magnet, was placed within the ring; but a reinforcing magnet slightly improved matters. Of course such an action in a Gramme armature going on in all the coils, except in those within 12° of the central line of the poles, would be most disastrous to the working of the machine; and the rise of potential round the collector would be anything but regular. In fig. 5 I have copied out Isenbeck's curve of induction for the consecutive four quadrants. From 0° to 90° the exploring coil is supposed to be vibrated in successive positions from the place where, in the actual dynamo, the negative brush would be, round to a point opposite the S pole of the pointed field-magnet. From 90° to 180° it is passing round to the positive brush; from 180° to 270° it passes to a point opposite the the N pole; and from 270° to 360° returns to the negative brush. Now, since the height of this curve, at any point, measures the induction going on in a typical section as it moves through the corresponding region of the field, and since in the actual Pacinotti or Gramme ring the sections are connected all the way round the ring, it follows that the actual potential at any point in the series of sections will be got by adding up the total induced electromotive force up to that point. In other words, we must integrate the curve to obtain the corresponding curve of potential corresponding with the actual state of things round the collector of the machine. Fig. 6 gives the curve as integrated expressly for me from fig. 5 by the aid of the very ingenious curve integrator of Mr. C. Vervon Boys. The height of the ordinate of this second curve at any point is proportional to the total area inclosed under the first curve up to the corresponding point. Thus the height at 90° in the second curve is proportional to the total area up to 90° below the first curve. And it will be noticed that though the induction (first curve, fig. 5) decreases after 90°, and falls to zero at about 102°, the sum of the potentials (second curve, fig. 6) goes on increasing up to 102°, where it is a maximum, and after that falls off, because, as the first curve shows, there is from that point onwards till 180° an opposing false induction. If this potential curve were actually observed on any dynamo we might be sure that we could get a higher electromotive force by moving the brush from 108° to 102°, or to 258°, where the potential is higher. Any dynamo in which the curve of potentials at the commutator presented such irregularities as fig. 6 would be a very inefficient machine, and would probably spark terribly at the collector. It is evident that the induction in some of the coils is opposing that in some of the adjacent coils.

FIG. 6.

Two questions naturally arise:—Why should such detrimental inductions arise in the ring, and how can they be obviated? The researches of Dr. Isenbeck supply the answer to both points. Dr. Isenbeck has calculated from the laws of magnetic potential the number of lines of force that will be cut at the various points of the path of the ring. He finds that the complicated mathematical expression for this case, when examined, shows negative values for angles between 12° and 90°. The curves of values that satisfy his equations have minima exactly in those regions where his experiments revealed them. This is very satisfactory as far as it goes. But we may deduce a precisely similar conclusion in a much simpler manner, from considering the form and distribution of the lines of magnetic force in the field. These are shown in fig. 7, together with the exploring coil situated as in fig. 4. A simple inspection of the figure will show that at 0° a certain number of lines of force would thread themselves through the exploring coil. As the coil moved round toward the S pole the number would increase at first, then become for an instant stationary, with neither increase or decrease; after that a very rapid decrease would set in, which, as the coil passed the 90° point, would result in there being no lines of force through the coil. But at the very same instant the lines of force would begin to crowd in on the other side of the coil, and the number so threaded through negatively would increase until the coil turned round to about the position marked T, where the lines of force are nearly tangential to its path, and here the inversion would occur, because, from that point onwards to 180°, the number of lines of force threaded through the coil would decrease. We see then that such inversions in the induction must occur of necessity to a small coil rotating in a magnetic field in which the lines of force are distributed in the curved directions, and with the unequal density which this disposition of the field-magnets presents. The remedy is obvious; arrange a more uniform field, in which the lines of force are more equally distributed and are straighter.

If an iron core be substituted for the wooden core the useful induction is greater, and the false induction less; there is still an

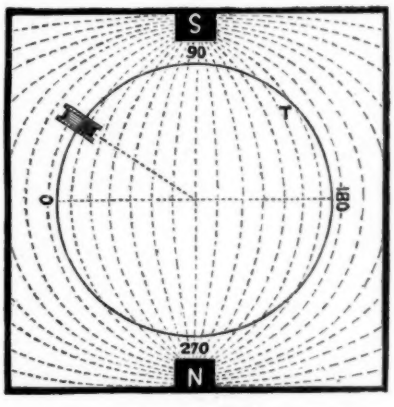


FIG. 7.

inversion, but it takes place at about 25° from the pole, and is quite trifling in amount. The introduction of iron pole-pieces extending in two nearly semicircular arcs from the magnets on either side has, if the wooden ring be still kept as a core, the effect of completely changing the induction, so that the curve, instead of showing a maximum at 90° from starting, shows one at about 10° and another at 170°. If, however, we make the double improvement of using the iron pole-pieces and the iron core at the same time the effect is at once changed. There are no longer any inversions, though the induction shows some peculiarity still. Fig. 8 shows the curve of induction adapted from Dr. Isenbeck's paper, and fig. 9 the curve of potential, which I have had integrated from it. Looking at fig. 8, we see that on starting from 0° induction soon mounts up, and becomes a maximum at about 20°, where the coil is getting well opposite the end of the encircling pole-piece. From this point on, though the induction is somewhat less, it still has a high value, showing a slight momentary increase as the coil passes the pole at 90°, and there is another maximum at about 160° as the coil passes the other end of the pole-piece. My integrated curve (fig. 9) tells us what would go on at the collector if this were the action in the connected set of coils of a

Pacinotti or Gramme ring. The potential rises from 0° all the way to close upon 180°. Still this is not perfect. In the perfect case the potential curve would rise in a perfect harmonic wave

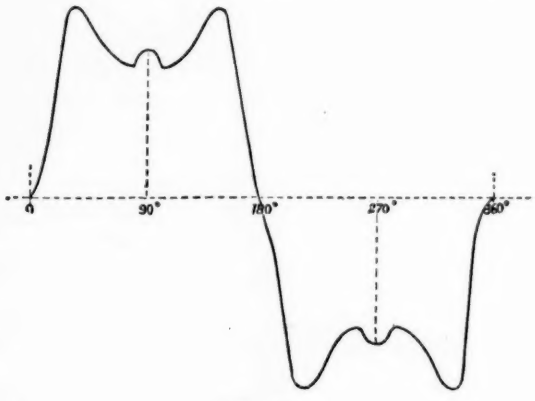


FIG. 8.

form, like that shown in fig. 2. Fig. 9 departs widely from this, for it is convex from 0° to 90°, and concave between 90° and 180°. But there are no inversions. The cause of the improvement is easily told: the field—such as there is between the pole-piece and the core—is "straighter," and the density of the lines of force in it more uniform. I proved this experimentally in 1878 by the simple process of examining the lines of force in such a field by means of iron filings; the actual filings, secured in their places

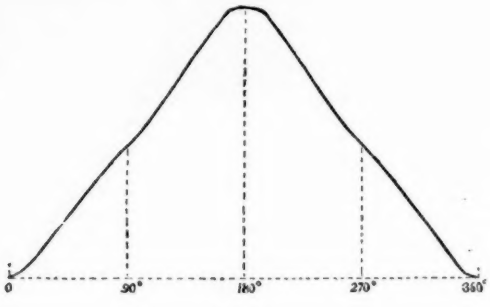


FIG. 9.

upon a sheet of gummed glass, were sent to the late Mons. Alfred Niaudet, who had requested me to examine the matter for him. Fig. 10 shows the actual field between the encircling pole-pieces and the iron ring. It will be seen that, though nearly straight in the narrow intervening region, they are not equally distributed, being slightly denser opposite the ends of the pole-pieces. One

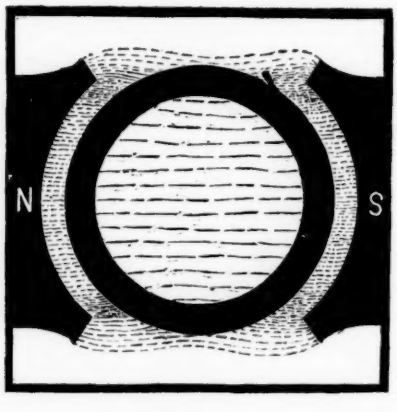


FIG. 10.

other case examined by Dr. Isenbeck we will glance at. The effect of introducing within the ring an interior magnet, having its S pole opposite the external S pole, and its N pole opposite the external N pole, was found to assist the action. The induction-curve is represented in fig. 11. As will be seen, there are two maxima at points a little beyond the ends of the pole-pieces, as before, but in between them there is a still higher maximum, right between the poles. This case also has been integrated on Mr. Boys' machine, and shows the potential curve of fig. 12. This curve is a still nearer approach to the harmonic wave-form, being concave from 0° to 90° and convex from 90° to 180°.

I pass from Dr. Isenbeck's researches, and the integrated curves of potential which I have deduced from them, to some further researches of my own, which were undertaken with the view of throwing some light on the question whether the Pacinotti form of armature, with protruding iron teeth, or the Gramme form, in which the iron core is entirely overwound with wire, is the better. It has been assumed without, so far as I am aware, any reason assigned, that the Gramme ring was an improvement on that of Pacinotti. Pacinotti's was of solid iron, with teeth which projected both outwards and inwards, having the coils wound between. Gramme's was made "either out of one piece of iron, or of a bundle of iron wires," and had the coils wound "round the entire surface." Now the question whether the Gramme construction is better than the Pacinotti or not, can readily be tested by experiment. And experiment alone can determine whether it is better to keep a thickness of wire always between pole-pieces and the core, or to intensify the field by giving to the lines of force the

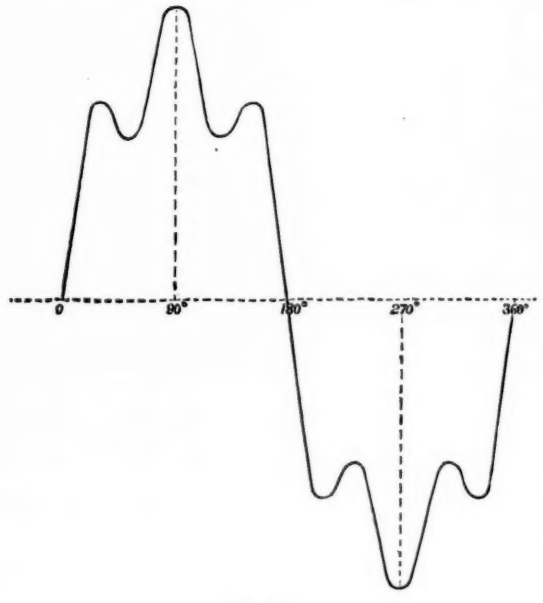


FIG. 11.

powerful reinforcement of protruding teeth of iron. The apparatus I have constructed for determining this point is sketched in fig. 13.

First, there are a couple of magnets set in a frame so as to give us a magnetic field, and there are pole-pieces that can be removed at will; in fact, there are three sets of pole-pieces for experimenting with different forms. Between the poles is set an axis of brass, upon which the armatures can be slid. These armatures are three in number. One is shown in figs. 14 and 15, and consists of two coils of fine wire wound upon a wooden ring; another armature is exactly like this, but is built up on a ring of iron wire; a third (shown in its place in fig. 13) is constructed upon a toothed ring made up of a number of plates of ferrotype iron cut out and placed flat upon one another. On each of the armatures are wound two coils at opposite ends of a diameter. The coils contain precisely equal lengths of silk-covered copper wire, cut from one piece. The cross section of the core within each of these coils is in each case a square, of one centimetre in the side, so that the number of turns in each coil is as nearly equal as possible. I can slip any one of these armatures into the field, and connect it with a galvanometer. There is a lever handle screwed to the armature, by means of which it can be moved. I have used two methods of proceeding in order to compare the coils. One of these methods is to turn the armature suddenly through a quarter of a revolution, so that the coils advance from 0° to 90°, when the "throw" of the needle of the galvanometer—which is a slow-beat one—gives me a measure of the total amount of induction in the armature. The results are as follows:—

Gramme. Wooden Ring.	Gramme: Iron Ring.	Pacinotti. Iron Toothed Ring.
5	24	50

My second method of using these armatures consists in jerking the coils through a distance equal to their own thickness, the coils being successively placed at different positions in the field. The throw of the galvanometer being observed as before. Each of the coils occupies as nearly as possible 15° of angular

breadth. Accordingly, I have two stops set, limiting the motion of the handle to that amount, and at the back, there is a graduated circle enabling me to set the armature with the coils in any desired position. If we move the coils by six such jerks, through their own angular breadth each time, then starting at 0°, the sixth jerk will bring us to 90°. I have plotted out in fig. 16 the three curves thus obtained, and the corresponding numbers are given in the following table :—

	Gramme.	Gramme.	Pacinotti
	Wooden Ring.	Iron Ring.	Iron Toothed Ring.
0°–15°	5	25	30
15°–30°	10	60	70
30°–45°	0	120	140
45°–60°	45	195	320
60°–75°	40	200	380
75°–90°	30	220	360

These figures leave no doubt as to the question at issue. The Gramme pattern of ring armature, so far from being an improvement on the Pacinotti, is distinctly a retrograde step; always supposing that the cost of construction, liability to heating, and other kindred matters be equal for the two. The significance of this point will be resumed at a later period in this paper.

Before leaving the theory of armatures, to pass to that of field-magnets, I should wish to say that the experiments which I have made, and also those of Dr. Isenbeck, have been so instructive to myself, that I have already begun a similar series of observations on other forms of armature. I hope in due time to make known the results of my investigations.

But little advance has been made in theory so far as relates to the field-magnets. The law of saturation of an electro-magnet

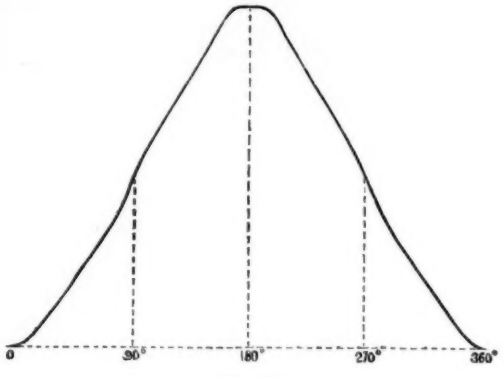


FIG. 12.

remains still an empirical law. It is satisfactory, however, that such widely differing authorities as Professor Clausius, M. Marcel Deprez, and Professors Ayrton and Perry agree in accepting the empirical formula of Fröhlich as a sufficiently accurate expression for the law of saturation.

Some progress has been made in the theory of the lead that must be given to the brushes of the dynamo. Formerly this was ascribed to a sluggishness in the demagnetisation of the iron of the armature; but in 1878, the late M. Antoine Breguet suggested as a reason the influence of the actual current circulating round the armature coils, which would tend to produce in the iron of the armature a magnetisation at right angles, to that due to the field-magnets.

Breguet showed that there would be a resultant oblique direction of the lines of magnetisation in the field, and therefore, since the "diameter of commutation" is at right-angles to this direction, the brushes also must be displaced through an equal angle. Clausius accepts this view in his recent theory, and adopts for the angle of the resultant field that whose tangent is the ratio of the two magnetising forces due to the field-magnets, and the current in the armature respectively. Professors Ayrton and Perry have also pointed out that there will be an additional displacement of the resultant pole of the armature, consequent upon the self-induction going on in the armature coil between its different sections. In their paper on the government of motors, in which they have brought out this point, they, however, take the view that part of the displacement of the pole is due to the sluggishness of demagnetisation of the iron. I do not think, however, that this can be maintained. No experimental proof has ever been given that there is any such thing as a true magnetic lag; the apparent magnetic sluggishness of thick masses of iron is demonstrably due to internal induced currents: and no one uses solid iron in armature cores for this very reason. Neither has it been shown that thin iron plates or wires, such as are used in armature cores, are slower in demagnetising than magnetising. Indeed, the reverse is probably true; and, until further experimental evidence is forthcoming, I shall assume that there is no magnetic lag in properly laminated iron cores,

It may here be pointed out that, assuming as a first approximation that the rule that the tangent of the angle of lead represents the ratio between the magnetising power of the field-magnets and of the armature coils, the lead may be diminished to a very small quantity, by increasing the relative power of the field-magnets, a course which is for many other reasons advisable. All practice confirms the rule that the magnetic moment of the field-magnets ought to be very great as compared with that of the armature. Further than this, there ought to be so much iron in the armature as to be just saturated when the dynamo is working at its greatest activity. If there is less than this, it will become saturated at a certain point, and when any currents greater than this are employed, the lead will alter, for then the magnetic effect due to the current in the armature will be of greater importance, relatively

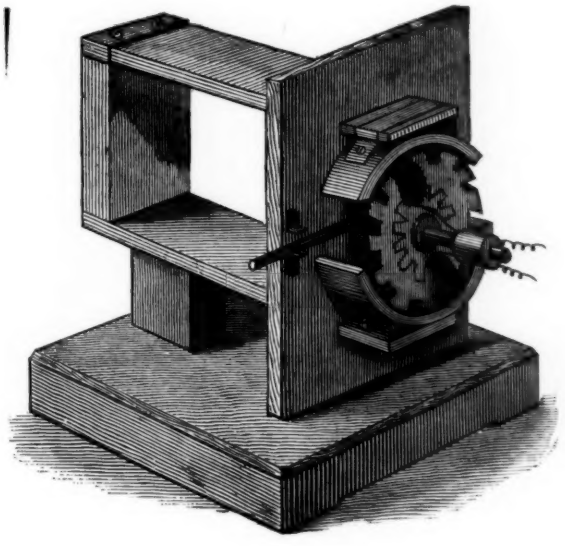


FIG. 13.

to that due to the field-magnets. For the same reason, the lead will be more constant when the field-magnets are under their saturation point, than when quite saturated. In short, every cause that tends to reduce the lead, makes the lead more constant, and therefore tends to reduce sparking at the brushes. And the best means to secure this is obviously to use an unstinted quantity of iron—and that of the softest kind—both in the field-magnets and in the armature, for then the currents circulating in the armature will have less chance of perturbing the field.

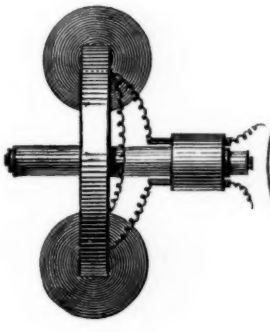


FIG. 14.

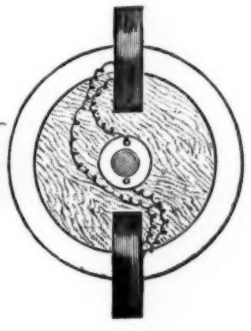


FIG. 15.

In relation to the magnetisation of field-magnets, it may be pointed out that the "characteristic" curves, now so much used for the study of the action of dynamo machines, which show the rise of the electromotive force of the machine in relation to the corresponding strength of the current, are sometimes assumed, though not quite rightly, to represent the rise of magnetisation of the field-magnets. Now though the magnetisation of the magnet may attain to practical saturation, it does not, under a still more powerful current, show a magnetisation less than saturation. But the characteristics of nearly all series-wound dynamos show—at least, for high speeds—a decided tendency to turn down after attaining a maximum; and for some machines, for ex-

ample, the Brush, this diminution of the electromotive force is very marked. The electromotive force diminishes, but the magnetism of the field-magnets does not. An explanation of this dip in the characteristic has lately been put forward by Dr. Hopkinson, in his lecture on "Electric Lighting," before the Institution of Civil Engineers, attributing this to the reaction of self-induction and mutual induction between the sections of the armature. No doubt this cause contributes to the effect, as all such reactions diminish the effective electromotive force. I am inclined, however, to think that the greater part of the effect is due to the shifting of the effective line of the field in consequence of the iron of the field-magnets becoming saturated before the armature is so. It is at least significant that in the Brush machine, where the reduction of electromotive force is very great, there is also such a mass of iron in the armature, and so variable a lead at the brushes.

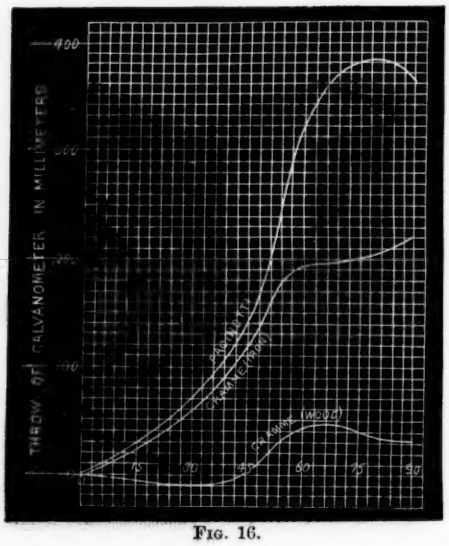


FIG. 16.

Another point in which theory has for long been ahead of practice, is in the advantage to be gained by working as nearly as possible with closed magnetic circuits; that is to say, with a nearly continuous circuit of iron to conduct the lines of magnetic force round into themselves in closed curves. The enormous importance of this was pointed out so far back as 1878 by Lord Elphinstone and Mr. C. W. Vincent, whose dynamo embodies their idea. Every electrician knows that if a current of electricity has to pass through a circuit, part of which consists of copper, and part of liquids—such as the acid in a battery, or the solution in an electrolytic cell—the resistance of the liquid is, as a rule, much more serious than the resistance of the copper. Even with dilute sulphuric acid the resistance to the flow of the current by a thin stratum is 200,000 times as great as would be offered by an equally thick stratum of copper. And in the analogous case of using a field-magnet to magnetise the iron core of an armature, the stratum of air—or, it may be, of copper wire—in between the two pieces of iron, offers what we may term a relatively enormous resistance to the magnetic induction. If we take the magnetic permeability of iron as 1, then the permeability of air is something like $\frac{1}{20000}$, and that of copper is not very different. Or, in other words, a stratum of air or copper offers about 20,000 times as much resistance to the magnetic induction as if the space were filled up with soft iron. Obviously, then, it would be a gain to diminish as much as possible the gaps between the portions of iron in the circuit. The values of the magnetic permeability for iron, air, and copper, have been known for years, yet this simple deduction from theory has been set at defiance in the vast majority of cases. We have had, a few minutes ago, an experimental proof that the Pacinotti ring, so far from having been "perfected" or "improved" by Gramme, as some very high authorities say, is vastly inferior to it. It will perhaps be intelligible now why Pacinotti's design was essentially right.

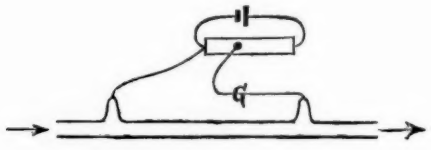
(To be continued.)

ON THE MEASUREMENT OF ELECTRIC CURRENTS.

By LORD RAYLEIGH, M.A., F.R.S. *

PERHAPS the simplest way of measuring a current of moderate intensity when once the electro-chemical equivalent of silver is known, is to determine the quantity of metal thrown down by the current in a given time in a silver voltameter. According to Kohlrausch, the electro-chemical equivalent of silver is in C.G.S. measure $1{\cdot}136 \times 10^{-2}$, and according to Mascart $1{\cdot}124 \times 10^{-2}$. Experiments conducted in the Cavendish Laboratory during the past year by a method of current weighing described in the British Association Report for 1882, have led to a lower number, viz., $1{\cdot}119 \times 10^{-2}$. At this rate the silver deposited per ampère per *hour* is 4·028 grams, and the method of measurement founded upon this number may be used with good effect when the strength of the current ranges from $\frac{1}{20}$ ampère to perhaps 4 ampères. It requires, however, a pretty good balance, and some experience in chemical manipulation.

Another method which gives good results, and requires only apparatus familiar to the electrician, depends upon the use of a standard galvanic cell. The current from this cell is passed through a high resistance, such as 10,000 ohms, and a known fraction of the electromotive force is taken by touching this circuit at definite points. The current to be measured is caused to flow along a strip of sheet German silver, from which two tongues project. The difference of potential at these tongues is the product of the resistance included between them and of the current to be measured, and it is balanced by a fraction of the known electromotive force of the standard cell.



(Fig 1.) With a sensitive galvanometer the balance may be adjusted to about $\frac{1}{40000}$. The German silver strip must be large enough to avoid heating. The resistance between the tongues may be $\frac{1}{200}$ ohm, and may be determined by a method similar to that of Mathiesen and Hockin (Maxwell's *Electricity* § 352). The proportions above mentioned are suitable for the measurement of such currents as 10 ampères.

Another method, available with the strong currents which are now common, depends upon Faraday's discovery of the rotation of the plane of polarisation by magnetic force. Gordon found 15° * as the rotation due to the reversal of a current of 4 ampères circulating about 1,000 times round a column of bisulphide of carbon. With heavy glass, which is more convenient in ordinary use, the rotation is somewhat greater. With a coil of 100 windings we should obtain 15 degrees with a current of 40 ampères; and this rotation may easily be tripled by causing the light to traverse the column three times, or what is desirable with so strong a current, the thickness of the wire may be increased and the number of windings reduced. With the best optical arrangements the rotation can be determined to one or two minutes, but in an instrument intended for practical use such a degree of delicacy is not available. One difficulty arises from the depolarising properties of most specimens of heavy glass. Arrangements are in progress for a redetermination of the rotation in bisulphide of carbon.

Query.—If the Schuckert machine patent is the property of the Anglo-American "Brush" Corporation, how is it that we find so many others freely using it?

* Extracted from the "Proceedings of the Cambridge Philosophical Society." Vol. V., Pt. I.

* Jan., 1884. In a note recently communicated to the Royal Society (*Proceedings*, Nov. 15, 1883) Mr. Gordon points out that owing to an error in reduction, the number given by him for the value of Verdet's constant is twice as great as it should be. The rotations above mentioned must therefore be halved, a correction which diminishes materially the prospect of constructing a useful instrument upon this principle.

THE NATIONAL TELEPHONE COMPANY.

NEW TRUNK SYSTEM IN GLASGOW.

IN Glasgow the National Telephone Company has adopted, so far as possible, the policy of opening subsidiary exchanges wherever a sufficient number of subscribers could be obtained, in order not only to give all firms the benefit of the system at the ordinary rate, although they were outside the usual radius from the centre of the city, but also to keep down, as much as possible, the mass of wires in the centre of the town.

So long as there were only three or four of these exchanges no difficulty was found in connecting them together by trunk wires, but when they increased in number—there are now seven in Glasgow—and as also the number of subscribers increased, it becomes a matter for consideration, how satisfactory and quick trunk service was to be given between these exchanges.

The system which has now been adopted and put into operation, is, we believe, already in use, in some form, in Paris, but not in any town in this country, and a short account of it may be interesting.

An exchange has been opened quite distinct from any of the other exchanges, and which is called the "Trunk Exchange;" it is connected with all the other exchanges by numbers of wires, varying according to the number of the subscribers in each exchange, the total number of Trunk wires now in use in Glasgow being 90. In the Trunk Exchange is an ordinary cord switch board, but with no indicators, and specially designed for quick service. From each exchange is a speaking wire to the "Trunk Exchange," which is in connection with a key on the operator's table. The mode of getting connected is as follows:—The operator wishing another exchange, presses the key which cuts her instrument into the speaking wire, and so puts the operator instantaneously in connection with the "Trunk Exchange." She then gives the name of her own exchange, and the name of the exchange wanted. The trunk operator at once, and by one movement, connects the wires which makes a direct wire between the exchanges wanting each other. As the trunk operator has simply the wires to connect, and nothing else to do, the connection is made very quickly. It has been carefully timed and it is found that communication is established in four seconds. It is found that the one operator can handle the 90 trunk wires with ease.

If the speaking wire was to go out of order it will be readily seen that the system would be seriously disorganised; but provision has been made against this by arranging that in the case of such a thing happening one of the other trunk wires can be substituted, and by the operators themselves.

The system is found to work admirably, and has tended to improve the service, there being now no delay in getting through from one exchange to another.

The work has been in progress for the last three months, but the final change was made about a fortnight since.

The whole work of designing and fitting up the apparatus and making the necessary alterations, and also in adapting the system to the special requirements of the system, has been carried out under the direction of Mr. D. Sinclair, the engineer and electrician of the company's Glasgow district.

A Contrast.—The war correspondent of the *Standard*, telegraphing on Sunday last, says:—There are in Suakim Harbour Russian, French, and Italian sloops of war. All these ships are furnished with the electric light and other modern scientific appliances. We have the *Euryalus*, *Carysfort*, *Briton*, *Dryad*, *Dragon*, all large cruisers, and the *Sphinx* and *Decoy* gunboats. Not one of all these ships has the electric light apparatus, and all are deficient in the scientific appliances with which the foreign vessels are supplied. Comment is needless, but the remarks here as to the neglect and apathy of our authorities in allowing all other nations to be so far ahead of our own are general and bitter.

THE ELECTRICAL TRANSMISSION AND DISTRIBUTION OF ENERGY.*

By MARCEL DEPREZ.

(*Continued from page* 193.)

Laws of the Action of the Generating Machines.

If we employ the machines as generators, they are subject to the following laws:—

1. The electromotive force of a given machine is proportional to the intensity of its magnetic field.

2. It is also proportional to the linear velocity with which the wires traverse this field, consequently to the angular velocity of the rotating ring, and to their distance from the centre.

3. It is also proportional to the length of the wires which constitute the coils of the ring.

These laws are merely the general laws of induction.

It must be remarked that these laws do not depend on the previous electric condition of the induced portion. It may, before setting the machine in motion, be traversed by a current, without anything being changed in its effects. The electromotive force which it generates is superimposed upon that produced by the former current; they are added to each other if of the same direction, and if they differ in direction the one is subtracted from the other. We may thus bring a battery into equilibrium with a magneto-electric machine.

If we employ a machine as a motor, we direct into its ring an external current which sets up inductive actions in the magnetic field and brings the ring into motion conformably with the 4th law of induction announced before. This developes a mechanical action by the sum of the elementary actions exerted upon each of its parts; and this action, as in all bodies which are obliged to take a movement of rotation, is measured by a combination—a system of two equal and parallel forces of opposite directions.

A fourth law is then manifested.

4. The mechanical action, the magnitude of the couple (product of the tangential effort by its distance from the centre) for a given machine is proportional to the magnetic field and to the intensity of the current; it is independent of the velocity impressed upon the ring.

A fundamental experiment demonstrates this law.

Suppose that we operate at first with a machine having permanent magnets as inductors; we submit it to the action of the current produced by a battery, and we place upon its revolving ring a Prony brake loaded with a constant weight. In this manner, when the ring turns, the machine furnishes a constant quantity of work per revolution. We must take care to place in the circuit a suitable galvanometer to indicate the intensities. We place elements successively in the circuit up to the number n_0; at this moment the machine gets into motion but very slowly. We may consider this point as the precise point where the resistance of the brake is counterpoised. We introduce an element more and the speed increases, the current remaining constant. We measure the speed thus attained and call it v. In place of one element let us place in the circuit 1, 2, 3, 4 ... n elements, in addition to the first n_0. We then see the velocity become $2v$, $3v$, $4v$ ... nv, varying proportionally to the increase of the number of the elements. According to the first law given on the subject of machines, the one in question cannot put itself in motion without generating an electromotive force inverse to that of the battery. This electromotive force will be proportional to the velocity of rotation, since the magnetic field produced by permanent magnets is constant; but we see that on the one hand the successive velocities—$2v$, $3v$ ... , nv—are proportional to n, whilst on the other hand, the elements of the battery added since the first starting are in number 1, 2, 3 ... n. It is easy to understand what must take place. In proportion as we add a new electromotive force to the battery, the current augments momentarily; the speed of the machine increases in proportion, since there is no longer an equilibrium between the motor-effort and the resistance. This increase continues until there has been created a counter-electromotive force compensating the former and keeping the current constant. The mechanical effort and the work per rotation remain the same; but as the number of rotations per unit of time increases, the absolute work increases also.

If we take a dynamo-electric machine the process is slightly different; but the result will be the same. If we suppose, in fact, that when the arrangement is once established the motive current increases, the counter-electromotive force of the working machine augments from two reasons. The one is that its velocity is accelerated, and the other that its magnetic field tends to increase. This counter-electromotive force will thus attend, as in the former case, until it has annulled the effect produced by the first force. But then, the current being reduced to the intensity of the arrangement, the magnetic field of the receiving machine is restored to its original value. The augmentation of its electromotive force is therefore due only to the augmentation of its speed, which must vary, as in the former case, in proportion to the augmentation of the positive electromotive force.

The important point to be noted among these experimental facts is that to a certain intensity of current in the machine employed

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* *La Lumière Electrique.*

as a motor, there corresponds a given mechanical effort, and one only. This result may be foreseen.

Suppose that we prevent a Gramme machine from turning, and direct into it a current of the intensity, I. At this intensity it exerts a well-defined effort against the obstacle, T, which arrests it. Suppose now that we cause the machine to work, and require of it the same effort; it cannot respond to the demand unless it receives this same intensity. Suppose that it receives a greater intensity, it will then develop into an effort greater than T. There will then be motive work greater than the resisting work, and the machine will move, being accelerated indefinitely. Whilst acting thus, it will develop a counter-electromotive force, increasing indefinitely, and this state of things will cease only when this counter-electromotive force has destroyed the excess of intensity, and brought back the current to its original value, I, which was to be proved.

We may draw from these remarks some interesting conclusions. Suppose that we return to the state of things at the moment when the battery contains n_0 elements. The intensity is then I, and there is expended in the battery a quantity of zinc, z, per element, or for the whole n_0 z, according to Faraday's law. Let us add n elements. The velocity of the recipient machine, which was nul, becomes $n\,v$, v being the velocity which it takes when we add one element to the n_0 already in the circuit. Let T be the constant work which the machine performs per revolution. At this new point, the intensity being still the same, the generating battery dissolves still a quantity, z, of zinc per element (Faraday's law). It consumes, therefore, $(n_0 + n)$ z, which gives us the measure of the total work which it produces according to the principle of the conservation of energy. This work is, therefore, proportional to $n_0 + n$ number of elements, *i.e.*, to the positive electromotive force, E. On the other hand the motor machine makes $n\,v$ revolutions, and the constant work per revolution being T, it produces $n\,v\,T$; the useful work is therefore proportional to n v, *i.e.*, to the counter-electromotive force, e, of this machine, which is proportional to its velocity, the magnetic field not having varied. Lastly, the relation of these two kinds of work, the economic return will be as $\frac{e}{E}$. We return thus by another way to the laws already given governing the transmission of energy in its different forms.

Let us now realise the experiment by constituting a real transmission of mechanical force, that is to say, by placing two machines in a circuit, the one acting as generator, and the other as recipient. For greater simplicity, let us suppose these two machines identical. The first is connected with any generator of force which may set it in motion. The second is in connection with some useful machine, or with a brake which imposes upon it a definite mechanical effort and a constant work per revolution. The first machine commences its movement, becoming accelerated by degrees, producing an electromotive force and an intensity which increase gradually up to the moment when the second machine, receiving a sufficient intensity, begins to move in turn and to perform work. From this moment the intensity is constant as it has been demonstrated in the foregoing paragraph, and if we continue to increase the speed of the former machine, that of the second will follow and increase in the same time.

The two machines being identical, and traversed by the same current, which, moreover, is constant, the mechanical efforts which they exert and the work per revolution are equal, in virtue of the foregoing principle, the velocities alone being different.

The work performed by the first machine is measured by the product of its speed and of the work per revolution. The work performed by the second is likewise the product of its speed and of this same work; the economic return is therefore measured by the ratio of these velocities.

But whatever may be these velocities, the current is constant; the resistance being invariable, the difference of the electromotive forces which produce it must be equally invariable; but the magnetic field being the same in the two machines, the respective electromotive forces are measured by the speeds of rotation. The difference of these velocities will therefore be constant. We see that the return is measured by the relation of two velocities, the difference of which is constant. It is, therefore, important to take the velocities as great as possible, in order to improve the result.

We may, therefore, figure to ourselves the transmission of mechanical power by electricity as a true transmission by means of a material such as a driving belt, connecting two machines fitted with equal drums. *The mechanical effort is effectively and entirely transmitted as if there was a material connection between the two machines.*

However, the driving belt thus supposed, slips and permits a difference of speed to be manifested between the generator and the recipient. The rate of this slipping is constant, and the difference of velocity between the two machines retains its value during the entire time of work. It depends on the charge of the second machine.

Numerical Application.

The laws of the transmission of mechanical power, which we have found *a priori* by the mere consideration of the general properties of energy are thus completely elucidated by experience.

One point remains for discussion, *i.e.*, to show how they may be immediately put in practice, with what simplicity they may be applied to apparatus actually in use, and what conclusions may hence be drawn.

This application will have the two-fold advantage of giving an example and showing numerically the reality of the laws enunciated. We cannot insist too strongly upon this point; this question being one of those on which doubts have prevailed for a long time, especially on the principle of returns independent of distance. At no very remote date, when I presented the announcement of this fact to the Academy of Sciences, in a memoir in the *Comptes Rendus*, it was received with very great mistrust, even by electricians.

In the reports of the best known experiments hitherto executed on this subject (Sermaize, Naisiel) it had been always represented that distance was a very injurious element, and the more considerable it was the thicker were the conductors required. Certain foreign *savants* magnifying this pernicious influence, went so far as to assert that to transmit to a distance the power of the Falls of Niagara would require a quantity of copper exceeding all that is to be found in the deposits of Lake Superior. I had, therefore, it will be admitted, some merit in affirming a truth hitherto misunderstood.

Recently, however, this truth has come to light, and by a reaction common enough in the history of the sciences, it has been boldly affirmed in lectures and in articles in learned journals, on the authority of English and American *savants*, that to distribute in the entire world the work of the above-named falls, a wire of $\frac{1}{2}$ inch English (about 13 millimetres) in thickness would suffice. If we reflect that the quantity of work in question represents at least two million horse-power, and probably much more, we must admit that the *savants* in question had not a very distinct idea of what these figures mean, or else that they have committed errors in calculation, which the absurdity of the result ought to have made them detect.

We find, indeed, that if we even suppose the internal resistance of the generating and recipient machines to be nul—which is absolutely inadmissible—and if we were content with transmitting the power to a distance of 75 kilometres (far from the entire world) it would be requisite to have a result of 50 per cent., that the generating machine should develope a force of 173,000 volts.

This result is easily obtained by means of the formula

$$T = \frac{E\,(E - e)}{g\,E};$$

the yield $K = \frac{e}{E}$ being given, we may at once infer that

$$E = \sqrt{\frac{g\,R\,T}{i - K}}$$

If, on the contrary, we take account of the inte rnal resistance o these machines, supposing it proportionally as s mall as in scm recently constructed by the firm of Siemens for galvanoplastic purposes, which is $\frac{1}{10000}$ ohm for an electromotive force of three volts, and if, besides, we neglect the resistance of the conductor, we find that the electromotive force would require to be $1\frac{1}{2}$ million volts, a fearful quantity, and of which the phenomena of lightning alone can give an idea.

The electromotive force of a Holtz machine is, according to Rossetti, about = 55,000 volts, *i.e.*, 27 times less than the number of volts just mentioned. Yet these machines give sparks of 0·20 metre in length. If the length of spark and the differences of potential are proportionate, a machine giving an electromotive force of 1,500,000 volts, would produce sparks nearly 6 metres in length.

It is theoretically certain that a wire of a diameter as small as might be desired, could transmit an unlimited quantity of energy, but on condition that the electric tension must be so much the higher as the transverse section of the wire is smaller. But a limit is imposed on this tension by the difficulties of insulation.

The authors of the project for transmitting the energy of the Falls of Niagara by a wire 13 millimetres in diameter, appear to regard these difficulties as overcome. But in that case, why fix on the figures of 13 millimetres and not take at once common telegraph wire of 4 millimetres in diameter? It would have been merely requisite to raise the tension at the source a little higher, and when we are calculating by millions of volts why hesitate at such a trifle?

If I insist on these improbable numbers it is merely to show that they are not the result of serious calculation, but that their object is simply to create a sensation and to bring on a reaction against the idea that very thick conductors are necessary. But the very exaggeration of this reaction tends to make us believe that the projectors of the wire of 13 millimetres had in this respect a sentiment rather than a well-founded opinion.

I purpose, on the contrary, to give on this question exact figures, and I am about—what, to my knowledge, has not yet been done—to solve the following problem:—

"Given an existing dynamo-electric machine submitted to dynamometric experiments in order to determine the work which it absorbs when employed for lighting, to find the results which may be anticipated when it is applied to the transmission of work through a conductor of known resistance."

To show how easily this subject may be treated without having recourse to multitudes of formulæ and symbols, I shall intentionally avoid algebraic notation as far as possible and employ merely arithmetical reasoning. This method possesses at least the advantage of throwing a strong light on the links of the argument and of, consequently, inspiring great confidence in the results obtained.

I shall take as example the Gramme machine, of the type C, and make use of the results obtained in the experiments conducted at Chatham.

I will assume in all that follows that the two machines, the generator and the recipient, are identical. This hypothesis is binding upon me, because if I suppose, unlike machines, the solution of the problem would require that I should know their *characteristic*, a special curve, the nature of which will be defined further on, and which we shall study when discussing the distribution of energy.

I shall take my stand upon the laws before laid down, and especially upon the considerations just developed concerning the transmission of a constant mechanical effort to a distance.

Another consideration is necessary. We have, in fact, to modify the arrangements of the existing machines in order to adapt them to this special purpose. Among the elements of these machines there is one whose law of variation is not well known. We do not know perfectly how the magnetic field is modified when the intensity of the current and the coiling of the wires are changed. In order to avoid this difficulty, we will not make the magnetic field vary in the machine, and to this end we remark that:

The intensity of the magnetic field does not vary when the product of the number of coils of wire on the bobbins of the exciting magnets into the intensity of the current is constant, on condition that the entire volume of the wire of the bobbins remains unaltered. If, *e.g.*, the wire of the magnets makes 1,000 turns, and if the intensity of the current is 10 ampères, the magnetic field produced may be obtained also with another wire of a smaller section, making 10,000 turns traversed by a current of 1 ampère on condition that the volume and the form of the bobbins are not changed. The section of the wire in this case must be $\frac{1}{10}$ of that of the original wire, supposing that the thickness of the layer of insulating material is proportional to the diameter of the bare wire. This law applies also to the magnetic field of the ring, as will be demonstrated in the second part of these investigations.

Having recalled these very simple laws I pass immediately to their numerical application, taking as an instance the Gramme machine, type C, experimented with at Chatham, and which gave the following results:

Revolutions per minute	1200
Intensity of current in ampères	81·22
Electromotive force, in volts	69·9
Work consumed in kilogrammetres, per second ...	570
Work per revolution in kilogrammetres	29
Resistance of the inductors, ohms	0·15
Resistance of the ring	0·06

Suppose that we give the wire of the inductors and of the ring a section equal to the fiftieth part of the primitive section, I say that their resistance becomes 2,500 times as considerable. In fact, the total volume of the wire not being changed, its length will become 50 times as great, but as its section is, on the other hand, 50 times less, the resistance becomes $50 \times 50 = 2{,}500$ times as great. We have then:

Resistance of the inductors, ohms	375
Resistance of the ring	150
	525

If we have two similar machines, a generator and a recipient, placed at the ends of an ordinary telegraph wire of galvanised iron, 4 millimetres in diameter and 50 metres in length, the total resistance will be decomposed as follows:

Generating machine, ohms	525
Wire (50 × 9), ohms	450
Recipient machine, ohms	525
	1,500

For the magnetic field to have the same value as in the Chatham experiments, the product of the number of coils of the inductor wire by the intensity of the current must remain the same (3rd law). But the inductor wire having a section 50 times less, and occupying the same volume, has a length, and consequently a number of coils 50 times greater. Consequently the intensity of the current necessary for the production of the magnetic field must be reduced to $\frac{1}{50}$ of its original value (81·22 ampères), or 1·624 ampères. The electromotive force necessary to produce this intensity in the total circuit is equal to $1{\cdot}624 \times 1500 = 2437$ volts. But as the wire of the ring makes 50 times as many coils round it as in the Chatham machine, the electromotive force of which it is the seat, becomes 50 times as great at an equal velocity, it will then be, at a speed of 1200 rotations per minute, be equal to $69{\cdot}9 \times 500 = 3495$ volts.

But as we do not require an electromotive force of 2437 volts (the recipient machine being motionless), the velocity must be reduced in the proportion of 2437 to 3495; it will then be equal to $1200 \times \frac{2437}{3495}$ revolutions per minute $= 835.5$.

As to the expenditure of energy necessary to maintain this current, it will be expressed by $\frac{E\,I}{g}$ or $\frac{2437 \times 1{\cdot}624}{9{\cdot}81} = 403$ kilogrammetres per second.

The number of turns of the wire of the inductors and of the wire of the induced parts being 50 times as great as in the Chatham machine, and the current 50 times less, it is evident, according to the third law, that the mechanical efforts developed between the inductors and the induced pieces remain the same; *i.e.*, if we cause the second machine to turn, keeping the intensity of the current (1·624 ampère) constant, it would give 29 kilogrammetres per revolution.

Consequently, if we wish it to produce 10 horse-power of work, or 750 kilogrammeters per second, it must make $\frac{750 \times 60}{29} = 1552$ rotations per minute. But in virtue of the fifth law, in order that the intensity of the current may remain constant, it is necessary that the difference of the velocities of the two machines should be also constant. The speed of the machine, must, therefore, be equal to $1552 + 835 = 2387$ revolutions per minute.

It must also be remembered that in virtue of the first and the fourth law, the mechanical efforts of the two machines are equal, and independent of their velocity, the current remaining constant. The generating machine will therefore absorb 29 kilogrammetres per revolution or per second $\frac{29 \times 2387}{60} = 1154$ kilogrammetres per second, or 15·4 horse-power.

The economic return, *i.e.*, the ratio of the work restored by the second machine to that absorbed by the first, will be expressed by:

$\frac{29 \times 1852}{29 \times 2307} = \frac{1552}{2378} = 65$ per cent.

The total work of 1154 kilogrammetres per second absorbed by the generating machine is accounted for as follows:—

	Kilogrammetres per second.
Work developed by the recipient machine ...	750
Thermic energy developed in the totality of the circuit	404
	1154

If we wish to know how the work absorbed by the heating of the circuit is distributed, we may calculate it directly by the formula $\frac{R\,I^2}{g}$ which gives:

For the generating machine:

	Kilogrammetres per second.
$\frac{525 \times 1{\cdot}624^2}{9{\cdot}81} =$	141

For the recipient machine:

$\frac{525 \times 1{\cdot}624^2}{9{\cdot}81} =$	141

For the outer wire:

$\frac{450 \times 1{\cdot}624^2}{9{\cdot}81} =$	121
	403

We see, therefore, that it is possible with two identical machines of the type C, to transmit useful work of 10-horse power to the distance of 50 kilometres by means of an ordinary telegraph wire, the original motive power being about 16-horse power.

The return will be in reality a little less, in consequence of the losses of work due to the parasitical induction currents, developed in the metallic masses in motion in the two machines, and also to friction, vibration, &c., the result of a very rapid rotatory movement.

It will be useful to examine the value of the electromotive force of the first machine, in order to form an idea of the perfection to which the insulation of the wires should be brought.

Its velocity being 2,387 revolutions, the resulting electromotive force will be approximately double that which corresponds to the velocity of 1,200 revolutions, which we found to be 3,495 volts, or exactly 6,952 volts. This is an electromotive force equal to 6,440 Daniell's elements.

It is certain that this tension requires a very careful insulation, but which, in my opinion, presents no insuperable difficulty, since, in order to explode mines, it has been for a long time customary to transmit the spark of an induction coil, the tension of which is much greater than 7,000 volts, to a distance of several kilometres. I think I have explained with sufficient detail the course to be followed in problems of this kind so as to show that they present no difficulty, and to place the reader in a position to appreciate the rigour and the extreme simplicity of the method which I have followed.

I cannot refrain from remarking in conclusion, that the theory of electric motors is much more simple than that of thermic motors. The problems concerning the latter lead, in fact, to questions almost always inextricable, and can be simplified only by admitting hypothesis incompatible with the reality. Thus, we cannot even in the present state of science, express by a precise equation the law of the adiabatic release of the vapour of water.

(To be continued.)

Post Office Employés.—Mr. Fawcett stated in the House of Commons on Monday, in reply to Mr. O'Brien, that since the 1st of April, 1881, sorting clerks and telegraphists had been granted extra pay for all extra duty in excess of two hours done on Sundays.

REVIEW.

The Modern Applications of Electricity. By E. HOSPITALIER. Translated and enlarged by Julius Maier, Ph. D. 2 vols. London : Kegan Paul, Trench & Co., 1, Paternoster Square.

In the present wholly revised edition a large number of important alterations and additions have been made with the view of giving an account of the numerous inventions which have during the last two years been made in practical electricity. The bulk of the matter has been taken from *La Lumière Electrique*, with but little alteration from the original text. Other sources of information have, however, been freely applied to, so that a very considerable amount of information has been collected.

The book commences with a short introduction on the sources of electricity. The chapter which follows this deals with "Electric Batteries." For a wonder we here find the name "Minotto" correctly spelt. The number of kinds of batteries, or rather "primary" batteries, described is large, and although the descriptions are not lengthy, they are quite as long as is necessary, so that we have a good deal of information compressed into a comparatively small space. This feature is a valuable characteristic of the book. With reference to primary batteries generally, the author states : "We reserve the battery for work where electricity is required, more for the rapidity and delicacy of its action than for its efficiency ; its application to telegraphy and telephony are instances of this. For electric lighting and for electromotors, where calories and work are required, the batteries labour under the disadvantage of burning a too expensive fuel-zinc, and also of burning it too slowly, which necessitates the use of a considerable number of elements, without yielding the corresponding available maximum work. Unless a complete revolution in the production of electricity by direct chemical action takes place, the principles with which we are acquainted now do not permit of the construction of a battery, at the same time powerful and economical, for applications which require these two qualities united to a very high degree." Thermo-electric batteries are next considered. These generators of electricity have not hitherto had much prosperity, though it is stated that the Nöe form is extensively used in Austria and Germany. The causes of failure in many of these apparatus has been due to the racking action which takes place through alternate heating and cooling. A great many of the Clamond piles failed from this cause. In the battery-room of the Submarine Telegraph Company a Clamond thermo pile has been in use for several years for working all the local circuits, and has never failed. This we believe is entirely due to the fact that the gas flame which heats the pile is *never* extinguished, so that the destructive changes of temperature do not take place. Thermo-piles, it is stated in M. Hospitalier's book, do not convert more than 4 or 5 per cent. of the heat expended into electricity, and therefore their future does not at present seem hopeful. In Chapter III. we have well-illustrated descriptions of the most important forms of dynamo-electric machines. We next have secondary batteries described, which concludes Part I. Part II., which forms the bulk of Vol. I., is devoted to "Electric Lighting," and is sufficiently complete to form a small treatise of itself.

In Vol. II. telephones, with the various appliances in connection with them, are described, and amongst others we have descriptions of apparatus for putting stations and subscribers into communication automatically, and at the same time cutting off subscribers who are in circuit at intermediate points, &c. The number of patents which have been taken out for such apparatus is legion, but in very few cases indeed have the same come into practical use, indeed, the ingenuity of the inventors seems almost wholly wasted. Part II. of Vol. II., deals with "methanometers," or apparatus for indicating the quantity of fire-damp in coal mines. We have also descriptions of "Fire Alarms," "Electric Water Gauges," "Electrical Appliances for Navigation," "Electrical Appliances for Meteorological Observations," &c. In Part. III. "Electric Motors" and the "Electrical Transmission of Energy" is described. Altogether "The Modern Applications of Electricity" is a very useful work, and is extremely well written and well illustrated. It does great credit to its authors.

NOTES.

Electric Lighting.—On Tuesday evening, the 4th instant, a number of gentlemen were invited by Messrs. Martin, Sons, & Co., to inspect the electric light at their works at Lindley, near Huddersfield. The installation consists of one Crompton-Burgin dynamo machine, and eight Crompton-Crabbe arc lamps, which light one half of the Burling Room. One Crompton-Burgin machine and 29 twenty C. P. Swan lamps are employed for lighting the offices, &c., and one machine and Crompton arc lamp, taking 28 ampères, in the dyehouse for the purpose of matching colours. The application of electric light was judged to be well adapted for the purpose. The lights were viewed with admiration, and their penetrating powers and resemblance to daylight were recognized with much satisfaction. The installation is pronounced on all sides a great success, and it is expected greatly to assist in the development of textile manufactures. This work has been carried out by Mr. Wilson Hartnell, of Leeds, under the superintendence of Mr. Francis Preston, C.E., of Kirkburton, Mr. Hartnell's district agent.

We note that it is finally determined by the London and South Western Railway Company to permanently light some of their trains by the latest inprovements which Mr. Holmes and Mr. Burke have made in their primary battery appliances. The first permanently-fitted carriage—a composite one, with four first-class compartments and two seconds—was attached one evening last week to the 4·55 Bournemouth express from Waterloo Station, and ran from London to Basingstoke, and returned thence by the Bournemouth up train due at about 8.0 p.m. in London. The battery which formed the source of the lighting was 3 feet 6 inches long by 1 foot square, and was said to weigh under 2 cwt. It maintained nine incandescent lights of five-candle power each, run up possibly to eight or more candle power of actual light. Two of these pretty lamps, within small clear cylindrical shades, were fitted in each first-class apartment, and one in the van in which the battery was carried. The lighting of the first-class compartments was spoken of as perfect. In every part of the carriage the reading of even small print was easy, without any effort or strain upon the eyes. The batteries are said to be able to work for 20 hours ; and the battery of nine cells, used effectively and continuously, worked for four hours without variation or diminution. The cost of the lighting is again stated to be one-eighth of a penny per hour per lamp, but it will be noticed that the lamp is no longer one of 10-candle power, as was formerly the case. The cost of fitting up the carriages would not, it is said, be one-half the cost of fitting for oil or gas ; and, whereas, for re-supply with gas the carriages have to be run into sidings specially for the purpose, the size and weight of Mr. Holmes's batteries would permit of an exchange being made at the platforms. The number of lights required for a complete train is estimated as 52, and the weight of a battery of cells for such lighting is said to be under 9 cwt.

We shall look forward with interest to the electric lighting at Paddington Station. Arrangements are being made for some 3,000 lights, to be used in connection with the alternating current machines of Mr. J. E. H. Gordon.

The trial of a new form of holophote, manufactured by Messrs. Siemens Bros. & Co., took place at the works

of Mr. P. Brotherhood, Belvedere Road, Lambeth, on the evening of Friday the 7th inst., and was witnessed by a number of experts representing the British Admiralty, Foreign Governments, Shipping Companies, &c., as well as by several members of the press. The holophote itself, which is to be placed on board Mr. Gordon Bennett's steam yacht "Namouna," embodies several novelties, which add greatly to its efficiency as compared with existing apparatus of the same character. The departure from former designs which constitutes the special feature of the new holophote are briefly enumerated below. As in earlier designs by the same makers, the light is concentrated into a beam of parallel rays by means of a Fresnel lens, but in the new holophote a lens of increased focal length is used so as to admit of it being placed sufficiently far from the arc to avoid any excessive heating of the lens itself, and there was on Friday night's trial ample evidence that the object aimed at was achieved, as the lens, after three hours run, was not sufficiently heated to prove inconveniently hot to the back of the hand. A plain glass screen in front of the lens, as well as a cylindrical hood protects it from possible splashings of sea water. Considerable range of motion is given in horizontal and vertical planes, and divided circles are provided to enable any determined inclination to be recorded and reformed if necessary. The conductors in the holophote itself are carried up the trunnion arms, and are readily accessible by the removal of certain cover plates, which are secured by screws, continuity at the joints being obtained by metallic slides. The usual coloured glass observing windows are provided, and a focus observer, giving an image of the carbon points. There is also an apparatus for transmitting signals by the Morse code, which has the advantage of allowing signals to be sent with the whole beam of light, either concentrated or dispersed by means of an additional lens, a result which has not been hitherto obtained, There is ample ventilation of the lantern. The lamp is regulated by hand, and rests on slides in such a way that it can be inclined at an angle, or be fixed vertically (when used with alternating currents) or be traversed to and from the lens to adjust its position at the focus. The carbons can be moved independently, or both together, by one hand-screw only, and the direction of the upper carbon can be varied so as to set it in and out of line with the lower carbon. The results obtained were considered to be very satisfactory. A dense beam of light of great steadiness was produced with a minimum of dispersion. The current through the lamp was 100 ampères, derived from a Siemens self-regulating Dynamo (S. D_0.), driven direct by a Brotherhood engine.

Gerard & Company, Limited, have obtained a diploma of honour from the Fisheries Exhibition for their installation of electric lighting.

Mr. C. H. Devey, of Lucan Lodge, Queen's Road, Clapham Park, gave two dances last week, when the rooms were illuminated both nights by incandescent lamps, under the superintendence of Mr. A. C. Devey. The current was supplied from 30 accumulators, which lasted for the two nights without requiring re-charging. Miss Devey excited much attention by wearing a small fairy lamp set in a star and fixed in her hair by a comb. The current for this was obtained from a secondary battery similar to those manufactured and supplied for the pantomime at Drury Lane by Messrs. Woodhouse and Rawson. In order to keep the fairy lamp continuously alight, two of these small accumulators were used, one being charged while the other was working. The large accumulators were Faure-Sellon-Volckmar, and together with the rest of the apparatus, were supplied by Messrs. Woodhouse & Rawson. The electric light allowed the complexions and dresses of the ladies, and the decorations of the rooms to appear to the best advantage. Nor was the usual inconvenience of crowded rooms, viz., closeness, experienced in the slightest degree.

The ss. *Cahors*, belonging to the Australian Steam Navigation Company, which has just been built by Messrs. John Key & Sons, of Kirkcaldy, has been lighted throughout with the electric light by Messrs. Woodhouse & Rawson, of 11, Queen Victoria Street, London. The effect of the lighting in the saloon is especially good, as no expense has been spared in fitting it up, the *Cahors* being considered as the finest and handsomest boat ever launched on the east coast of Scotland. The saloon is fitted with satinwood throughout, and has parquet flooring. The installation consists of 133 Woodhouse & Rawson incandescent lamps, 50, 20 and 10 C.P. running on the same circuit, the current being supplied from a Burgin self-regulating machine. For lighting the hold, a group of three 50-C.P. lamps has been used, encased in a large globe, which is capable of being raised and lowered as required, having a reflector above, with a suitable arrangement for insulation of the wires. This is especially useful at any time, as it can also be hauled up in the rigging, and completely lights up the deck. Two of these groups have been fixed, one fore and the other aft. This is the second ship that Messrs. Woodhouse & Rawson have lighted up for the same shipbuilding firm.

We are informed on good authority that Messrs. Paterson & Cooper, in spite of opposition offered by a certain individual, have secured the lighting contract for portions of the Leeds New Municipal Buildings. The highest and lowest tenders sent in were £1,791 14s. 10d., and £1,203 11s., respectively. The successful estimate stands, we believe, almost midway between the above sums. The work is to be completed in two months. That Messrs. Paterson & Cooper should have obtained this contract is very gratifying, for we think the opposition offered to them, practically after the matter was decided, was of a most unfair description. Competition is one thing, but to exert influence after a decision has been arrived at, and to make disparaging statements and inuendos in the endeavour to undo an advantage fairly gained by a competitor, is quite another.

The installation of electric lighting mentioned by us last week in connection with the letter which appeared in the *Graphic*, giving an account of the temporary lighting of a ballroom, was carried out by Messrs. Laing, Wharton, & Down, and it is only one of many instances in which this firm has put up similar installations, and with the greatest success.

An Electric Lighting Case.—Stockman *v.* Muir.—This case, the details of which are interesting to electric light engineers and amusing into the bargain, was finally decided in Edinburgh on March 6. In 1882 Mr. Stockman, a civil engineer in London, accepted a contract to light Mr. Muir's house on the island of Inistrynich, Loch Awe, with one arc and from 35 to 40 incandescent lamps, and completed his undertaking in September of that year, the price agreed upon being £320, Mr. Muir finding engine, boiler, and driving gear. A Siemens shunt dynamo was employed, but the gearing provided did not meet with Stockman's approval, as with it the engine had to be driven so slowly that the governor did not come into play; but the defender did not think fit to alter it, preferring to trust to the skill and watchfulness of his engineer. After working well for some weeks, the lamps in the billiard-room suddenly went out, and refused to re-incandesce. Muir, instead of obtaining the services of an electrician, employed a plumber to discover and remedy the defect. After divers attempts at finding the fault, during which most of the billiard-room fittings, pendants, &c., were taken down, it was found that when the switch which controlled the billiard-room lights was cut out the lamps would burn. The plumber thereupon connected the billiard-room system direct to the main wires. But very shortly the billiard-room lamps failed again, and this time every lamp in the house followed suit, suffering simultaneous extinction, and leaving the place in darkness. Now the plumber was at fault, and after industriously taking down and altering the wires for some days, gave it up

as a bad job. Thereupon Muir refused to pay Stockman's account, on the plea of bad workmanship; legal proceedings were taken, and Mr. Alfred R. Bennett was commissioned to examine and report upon the installation. This gentleman found that the original failure of the billiard-room lamps had been caused by the fusing of the safety wire in the switch which controlled them, owing to the engine having been overdriven; and that the second and final failure had been occasioned by a short circuit in the billiard-room between two wires which had been unskilfully manipulated by the plumber. The second failure—the switch having been cut out—was of course followed by the extinction of every lamp in the house. The billiard-room wires which had been short-circuited bore signs of great over-heating, the insulation being melted and charred. With these facts before him, Lord M'Laren gave judgment in November last in favour of Stockman, with expenses. Muir appealed, with the result that the judgment has been unanimously confirmed by the four judges of the Inner Court, with additional expenses. The *élite* of the Scotch bar has been employed in the case, the Lord Advocate (Mr. Balfour, M.P.) representing Stockman, and the Dean of the Faculty (Mr. Macdonald) Muir. The defender has consequently been heavily mulcted. It was stated in Court that the cost of a new pulley of the size desired by Stockman, which would have rendered overdriving impossible, was £2 (!).

The Gramme Patents.—Wednesday, the 2nd of April next, has been fixed by their lordships, the Judicial Committee of Her Majesty's Privy Council, for hearing the petition of the British Electric Light Company for a prolongation of the term of the letters patent granted to Zenobe Théophile Gramme and Eardley Louis Charles D'Ivernois, of Paris. We learn that the petition will be opposed by five distinct parties.

Metropolitan Brush Electric Light and Power Company, Limited.—A petition, presented by the committee of investigation, Messrs. A. M. Peebles, L. Engel, G. J. F. Andreæ and Admiral Sir E. A. Inglefield, for the winding up of this company, was heard before Mr. Justice Kay on the 7th inst. Mr. Graham Hastings, Q.C., and Mr. Barton Buckley, appeared for the petitioners, and Mr. Maclean for the company. The voluntary liquidation was ordered to be continued under the supervision of the Court.

Telephony.—On Saturday last the Edison Gower-Bell Telephone Company, of Lisbon, had the honour of transmitting the opera "Lauriana" by telephone to the Ajuda Palace of the King of Portugal. As this was the first performance in Portugal of this opera, which is composed by a Portuguese, the king and the court were much disturbed at being unable to attend, owing to the recent decease of the late Princess of Saxony. However, the difficulty was overcome by the opera being transmitted by telephone. The arrangements at the Opera House consisted of six microphone transmitters, connected in multiple arc, two of them being Blake transmitters, and the remainder Gower-Bell. Four were placed on the bases of the columns in front of the curtain, about six feet above the stage, and two, on either side of and behind the prompter's box, were one foot above the stage. All the instruments were placed on lead supported by soft India rubber pedestals, in order to lessen as much as possible the effects of extraneous vibrations. A metallic circuit of ten miles of wire was employed, and any transmitter could be cut out without disturbing the remainder. Each transmitter had three sets of two Leclanché batteries each, which were switched on in succession every twenty minutes, on account of the rapid polarisation of these batteries when on short circuit. Whenever the bass and more metallic instruments of the orchestra were brought into full play, two of the Gower-Bell transmitters and occasionally a third were cut out, to avoid the jarring effect which would otherwise have been produced. At the receiving end, in the palace, ten Gower-Bell receivers were placed. The telephones were themselves hidden from view by flowers, from which emerged the two ear tubes of each receiver. The whole of the royal family and a distinguished party heard the opera by these means. The king afterwards expressed his complete satisfaction, the transmission being perfect and even the words of the singers being understood. The arrangements were under the direction of Mr. Alan Danvers, the company's representative and engineer in Lisbon.

The *Stockholms Bell Telefon Aktiebolag* gives the following interesting particulars as to the position of the telephone at the end of 1883. Stockholm with 190,000 inhabitants has 1,193 subscribers, who are divided over three exchanges, worked day and night by 60 young ladies. There are also public telephone stations whence the inhabitants in the suburbs can talk for five minutes with the subscribers to the telephone exchange for a charge of 15 centimes (1½d.). This is, then, the realisation, on a small scale, of the scheme of penny telephone messages in the metropolis advocated by Mr. J. W. Batten, one of the directors of the United Telephone Company, as long ago as December, 1881, in an address to the Statistical Society. The practicability of the scheme is fully illustrated by its successful working in Stockholm. If it can answer in a comparatively small city like Stockholm, and with a telephone exchange of 1,193 subscribers, how much more promise would not the system hold out in the metropolis with its large population whose interests are so closely concerned with many of the 3,200 subscribers of the London Exchange. The subscription at Stockholm is £10 16s. per annum. There are 420 subscribers at Gothenburg, 284 at Malmoe, 171 at Sundswaal, and 73 at Soderhaum; the subscription varying from £6 16s. to £9. In several other small towns telephone systems are established by a mutual association of inhabitants, in this way, that once the installations are made and paid for by the subscribers themselves, they have no more to pay than the exact amount of the cost of maintenance. Allowed to develope so freely, and free from Post-office royalties, it is no wonder that the telephone is making such rapid strides in Sweden. One is apt to get envious of what one may truly call "free trade" for the telephone.—*Postal Gazette.*

The *Bradford Observer* of Monday last published a lengthy article on the telephone, and from the information therein given we learn that it is less than three and a-half years since the exchange of the National Telephone Company was opened in Bradford with half-a-dozen subscribers, who at that time used the telephone rather less than four times per day each. In Manchester there are about 700 subscribers on the exchange, who make 4,000 calls, or an average of nearly six each per day. The Bradford exchange was opened in October, 1880, with six subscribers and a total of twenty-three calls. In April, 1882, there were 135 subscribers, with an average number of calls of 2·11 each per day. In April, 1883, the number of subscribers had increased to 224, with an average of 4·08 calls, while at the present time, with 280 subscribers, the average number of calls has risen to 7·12 for each subscriber daily. In Leeds the number of subscribers is 260, the total number of calls per day 926; in Huddersfield, with fifty subscribers, there are 194 calls; at Dewsbury, with seventy-two subscribers, 263 calls; at Halifax, with thirty-three subscribers, 88 calls; and at Wakefield, where an exchange has only just been opened, seven subscribers, with three calls.

Telephone Wires.—In reply to a request from the Bethnal Green Vestry, that the Metropolitan Board of Works would oppose the United Telephone Company's bill, that board stated that they had decided to petition against it, thinking that the powers sought for the company were greater than should be conferred upon any commercial company. Should, however, these powers be granted, it was desirable that there should be

one authority to sanction the wires, and that that should be the Metropolitan Board of Works. The control of the vestries, however, over the roads in their respective districts should not be interfered with, and the petition would ask that any works to be done by the company in question should be performed to the satisfaction of such vestries.

Eastern Telegraph Company, Limited.—Commenting on the action of this company in placing their wires at the disposal of the wounded officers and men at Suakim who might be anxious to communicate with their friends at home, the *Standard* says :—"This action on the part of the Eastern Telegraph Company is one of those good deeds which deserve the reward of publicity. Such a concession would have been graceful and praiseworthy even if it had been made at a period when the wires were comparatively idle ; but the addition of some hundreds of free messages at a time when the machinery of the telegraph is strained to the utmost to get the despatches through with speed and accuracy—makes this thoughtful care for the wounded doubly precious, and will, we feel sure, be rightly valued, not only by the immediate friends of the sufferers, but by the country at large."

Her Majesty's Postmaster-General v. the Cambrian Railways Company.—Mr. Justice Mathew delivered judgment in this case on Friday, the 7th inst. By an agreement made on the 31st of December, 1873, the defendants agreed to grant free passes for stores used in the maintenance of, and to persons engaged in maintaining, the telegraphs, but declined to grant them except on the conditions that those using them should travel at their own risk, and that the defendants should not be liable for any injury to the passenger or his luggage. It was stated that on several other railways free passes were granted to which those conditions were not attached, and his lordship was of opinion that the expression "free pass" has not any such customary meaning as that contended for by the defendants. A *mandamus* was therefore granted directing the defendants to issue free passes without the conditions. Judgment was also given for the amount to be ascertained which had been paid in consequence of the defendants' refusal to grant free passes except on conditions.

Compagnie Francaise Du Telegraphe De Paris a New York v. Penzance Union.—This, a special case stated for the opinion of the court, came before the Lord Chief Justice and Mr. Justice Cave on March 9th, and raised a question as to the liability of the appellants, the Telegraph Company, to be rated for the relief of the poor. The appellants owned certain submarine telegraph cables between France and America, and also worked certain submarine cables between France and a point on the Cornish coast near Land's End, and carried on the business of a telegraph company in connection therewith. Under an agreement with the Postmaster-General the appellants were to have the use of two telegraph wires, extending from Penzance to the landing-place of the telegraph cable at Land's End. The wires passed through the parish of St. Buryan, in the Penzance Union, and the assessment committee of that union included in their valuation the appellants as persons liable to be rated for the relief of the poor in respect of the alleged occupation of such wires. The question raised was whether this exclusive use of two wires was a beneficial occupation of the land through which they passed so as to be subject to the rate. Mr. Justice Cave gave judgment in favour of the appellants, in which the Lord Chief Justice concurred, but leave was given to the respondents to appeal.

Gas and Electricity.—A firm of millers, who have tested the relative cost of gas and electricity in their flour mills, give the results of their experience. The use of gas for three thousand hours cost them £150. The cost of fitting up the plant for the electric light was £130, but after that, the expense of lighting, including interest on outlay, for a similar number of hours, was £43. This result was gained by utilising the existing-motive power, and driving the dynamo from the mill-engine. Of course extra coals would be necessary, but the millers consider that a large proportion of the balance of £107 would be left after meeting this expenditure. In addition to this there are the advantages of no heat, no smell, and security against fire.

Legal.—A jury at Edinburgh recently awarded Benjamin Wyllie £150, as damages, for injuries received by the fall of a telegraph pole at Garngad Railway Station. The defenders (the North British Railway Company), have applied for a new trial. The judge's notes of the evidence have been ordered to be printed, and the motion for a rule on the pursuer to show cause why a new trial should not be allowed, has been put on the roll for discussion.

Telpherage.—Under the auspices of the Glasgow Science Lectures Association, Professor Fleeming Jenkin, of Edinburgh, on Friday week gave the first public exposition of "Telpherage, or the Automatic Transport of Goods by Electrical Means." Sir William Thomson, in introducing the lecturer, said that Professor Jenkin, after having done so much for submarine communication, had now turned his attention to the carrying of goods and passengers through the air by electricity, and that excellent results might be looked for from his very beautiful invention. Professor Jenkin, at the outset of his address, explained the origin of the word "telepherage," and said that the old story of a person hanging a pair of boots on a telegraph wire, and expecting that they would find their way to a distant friend, had set him thinking about the possibility of really carrying the idea into practical use. We gave a full description of telpherage in our issue of 8th December last, so that it is unnecessary to repeat it now. With the aid of a model railway built upon the platform, the lecturer made his system clear to his hearers, who frequently demonstrated their appreciation, and greeted the successful running of the trains with applause.

Overhead Wires.—A meeting of representatives of the Post Office, the Local Government Board, and the Board of Trade, and of certain telephone companies, took place on Wednesday at the Post Office. It is understood that an announcement was made that the Government would oppose all private legislation on the subject of overhead telegraph and telephone wires, and would not themselves introduce into Parliament any general measure until the termination of the litigation now pending.

A Testimonial.—On Saturday, March 1st, the *employés* and a few friends of Messrs. H. & E. J. Dale presented a testimonial to Mr. H. J. Dale, as a mark of their confidence and esteem. We may also mention that at the Calcutta Exhibition the bronze medal and certificate was awarded to Messrs. H. & E. J. Dale, for their patent multiplex camera back, and excellence in photographic cabinet work.

Electric Bells.—The illustration here given explains itself. The design is that of Messrs. Eidsforth & Mudford, who have sent us a specimen of the result of their endeavours to make electric bells appear more artistic.

Sir William Siemens.—We have received from the Universal Printing Company, of 280, High Holborn, an Indiaproof engraving of the late Sir William Siemens. The work is excellent, and the likeness the best we have seen.

NEW COMPANY REGISTERED.

Deal and Walmer Electric Light Company, Limited.—Capital £5,000 in £5 shares. Objects: To supply electricity within the borough of Deal and the parish of Walmer for public and private purposes within the meaning of the Electric Lighting Act, 1882. Signatories (with one share each): W. Chesterfield, P. A Frost, D. M. Hills, J. Stroud, A. E. Ralph, H. G. Frost, T. S. Bayly, all of Deal. The signatories are to nominate the first directors and the first secretary. Registered 10th inst., by S. G. Warner, 6, Quality Court, Chancery Lane.

OFFICIAL RETURNS OF ELECTRIC COMPANIES.

Indian and Oriental Electrical Storage and Works Company, Limited.—An agreement, dated the 2nd ult., was filed with the documents of this company on the 10th inst., in accordance with which, the Electrical Power Storage Company, Limited, agrees to surrender to the Indian Company the 5,000 fully paid ordinary shares now held by them in consideration of an allotment of 10,000 fully paid deferred shares, formerly of £5 each, but now of the nominal value of £3 10s. each. In the event of the reduction of capital by the Indian Company not being confirmed by the Court, the Storage Company will accept 7,000 fully paid deferred shares of £5 each, in lieu of the aforesaid.

PROCEEDINGS OF SOCIETIES.

Physical Society, March 8th, 1884.

Prof. GUTHRIE, President, in the chair.

Lord RAYLEIGH read a paper on the "Electro-chemical equivalent of silver." The determination was made by a method described to the last meeting of the British Association at Southampton, which consists of using two fixed coils and a moveable coil suspended between these from one end of a balanced beam. These coils are in circuit with the current and voltameter. The current is reversed in the fixed coils at intervals of 5 minutes, and the weight required to bring the balance even is noted. The calculation of the effect by this method is independent of the precise measurement of the coils. Two or more silver voltameters were in circuit, nitrate of silver being the solution used. Careful precautions of various kinds were taken, and the result was that unit C.G.S. current deposits $1{\cdot}118 \times 10^{-2}$. It follows that 1 ampère will deposit 4·025 grammes of silver per hour. (See our other pages.

Lord RAYLEIGH also read a paper on the "Absolute electromotive force of Clark's cell. Experiments made at the Cavendish laboratory gave the electromotive force of this cell as 1·453 volts. The accepted value is 1·457 volts. If the B.A. unit (as Lord Rayleigh believes) is about ·9867 of a true ohm, the result 1·453 becomes 1·434 volts. Lord Rayleigh also mentioned that he had been making experiments on the rotation of the plane of polarised light in bisulphide of carbon, and obtained a result agreeing more nearly with Gordon's than Becquerel's.

Profs. GUTHRIE and AYRTON spoke on the papers: the former eliciting the reply that electro-corrosion was less satisfactory than electro-deposition for determining the equivalent; and the latter that silver was better than copper for accurate results in the voltameter.

Mr. SHELFORD BIDWELL, M.A., read a paper on "Some experiments illustrating an explanation of Hall's phenomenon." By these experiments Mr. Bidwell sought to explain Hall's effect through a combination of mechanical stress and the well-known Peltier effect on the thin metal plate which is placed between the poles of the magnet. He repeated many of the experiments, and showed how he had obtained the same results as Hall, except in the case of aluminium, which he found to be + like iron, whereas Hall made it −. Mr. Bidwell reversed the effect by cutting two slits in the strip of metal, thereby altering the stress on it. Righi's effect was also explained on the same grounds.

Mr. WALTER BROWNE said that difference in the quality of the aluminium might explain the anomaly with this metal.

Prof. PERRY criticised the explanation of the slitted plate.

CITY NOTES, REPORTS, MEETINGS, &c.

The India Rubber, Gutta Percha, and Telegraph Works Company, Limited.

An extraordinary general meeting of this company was held at the Cannon Street Hotel on Wednesday, Mr. George Henderson presiding, when the following resolution, passed at the general meeting on the 26th ult., was confirmed:—"That the sanction of the India Rubber, Gutta Percha, and Telegraph Works Company, Limited, be given to the Bill introduced into the present Session of Parliament, entitled 'An Act to define and extend the powers of the India Rubber, Gutta Percha, and Telegraph Works Company, Limited,' and for other purposes; subject to such alterations, additions, or variations as Parliament may think fit to make."

Brazilian Submarine Telegraph Company, Limited.—The directors have declared an interim dividend of 3s. per share, or 6 per cent. per annum, tax free, for the quarter ended December 31st, payable on the 25th inst. The transfer books will be closed from Tuesday, the 18th, to Monday, the 24th inst., both days inclusive.

Maxim-Weston Electric Company, Limited.—The works of this company are removed from Bankside to Holywell Lane, Great Eastern Street, E.C.

LATEST QUOTATIONS.

Authorised Issue.	Share.	Name.	Paid.	Closing Quotatns. Mar. 12.	Business Done.
		ELECTRIC LIGHT.			
40,000	10	Anglo-American Brush Co.	8	1⅞ - 2	
		Do.	10	4 - 4½	
30,000	5	Australasian E. L., Power & Storage Co.	3½	..	
24,900	10	British Insulite Co., Ld., "A" Shares..	5	..	
30,000	5	Brush Elec. Lt. & Power Co. (Scotland)	2½	..	
25,000	5	Gt. Western Electric Light & Power Co.	2½	⅛ - ¼	
24,980	5	Hammond Elec. Lt. & Power Sply. Co.	5	1¾ - 1⅞	
40,000	5	Indian & Ori. Electl. Storage Wks. Co.	2½	..	
250,000	1	Maxim-Weston Elec. Lt. & Power Co. .	1	⅜ - ½	
100,000	5	Metrop. Brush Electric Lt. & Power Co.	3	..	
40,000	5	Pilsen-Joel & Gen. Elec. Lt. Co.	2½	..	
20,000	5	S. African Brush Elec. Lt. & Power Co.	2½	..	
100,000	5	Swan United Electric Light Co., Ld.	2½	⅜ - ½	
		TELEGRAPHS.			
1,892,480*l.*	Stk.	Anglo-American, Limited	100	38 - 39	
2,553,780*l.*	Stk.	Do. Pref. } Def. receiving no div. until	100	66½ - 67½	66⅝
2,553,760*l.*	Stk.	Do. Def. } 6 p. c. paid to Pref.	100	9 - 9½	
130,000	10	Brazilian Submarine, Limited	10	9½ - 9⅝	9⅝, ½
16,000	10	Cuba, Limited	10	10 - 10½	10½
6,000	10	Do. 10 per cent. Preference ..	10	17 - 18	
13,000	10	Direct Spanish, Limited	9	4⅛ - 4⅜	
6,000	10	Do. 10 per cent. Preference ..	10	14½ - 15½	
65,000	20	Direct United States Cable, Ld., 1877 ..	20	10½ - 10⅝	
100,000*l.*	100	Do. 6 per cent. Deb., repayable 1884	100	100 -103	
380,000	10	Eastern, Limited	10	10⅝ - 11⅛	
70,000	10	Do. 6 per cent. Preference	10	13 - 13½	
232,000*l.*	100	Do. 6 do. Debs., repayable Oct. 1883	100	..	
200,000*l.*	100	Do. 5 do. do. Aug. 1887	100	100-103	
200,000*l.*	100	Do. 5 do. do. Aug. 1889	100	102-106	
250,000	10	Eastern Exten., Australasia & China, L.	10	11 - 11¼	
320,000*l.*	100	Do. 6 p. c. Debs., repayable Feb. 1891	100	107 - 110	
500,000*l.*	100	Do. 5 p. c. (Aus. Gov. Sub.) Deb. 1900	100	102 - 105	103½
140,000*l.*	100	Do. do. reg., repayable 1900..	100	102 - 105	
100,000*l.*	100	Do. 5 per cent. Debenture, 1890	100	102 - 105	102
550,000*l.*	100	{ Eastern & South African, Ld., 5 p. c. } { Mort. Deb. Rg. redeemable 1 Jan. 1900 }	100	102 - 105	
	100	Do. do. do. To Bearer..	100	102 -105	
22,050	10	German Union Telegraph & Trust, Ld.	10	10 - 10½	
250,000	10	Globe Telegraph & Trust, Ld.	10	6¾ - 6⅞	
250,000	10	Do. 6 per cent. Preference ..	10	12½ - 12⅝	
150,000	10	Great Northern	10	13⅜ - 13⅝	
100,000*l.*	100	Do. 5 per cent. Debentures ..	100	101 -104	
300,000*l.*	100	Do. 5 per cent. Debentures ..	100	101 -104	
81,200	10	India-Rubber, Gutta-Percha, & Tel. Wks.	10	21½ - 22½	
100,000	100	Do. 6 per cent. Debs., 1888	100	102 -105	
18,000	25	Indo-European, Limited	25	29 - 31	
40,000	10	London Platino-Brazilian, Limited	10	3¼ - 3⅜	
12,000	10	Mediterranean Extension, Limited	10	11⅛ - 11⅜	
3,200	10	Do. 8 per cent. Preference	10	2 - 4	
10,000	8	Reuter's, Limited	8	9 - 9½	
338,225*l.*	Stk.	Submarine	100	190 -200	
75,000	1	Do. Scrip	1	1⅝ - 2⅛	
4,200	Cert.	Submarine Cables Trust	100	99 -105	
37,350	12	Telegraph Construction and Mainten.	12	33 - 34	34
150,000	100	Do. 6 per cent. Bonds, 1884 ..	100	105 -108	
180,750	5	Do. 2nd Bonus Trust Cert. ..	2½	1⅛ - 1⅜	
30,000	10	West Coast of America, Limited	10	6 - 6½	6⅞
150,000*l.*	100	Do. 8 per cent. Debs.	100	107 -110	
43,791	15	Western and Brazilian, Limited	15	5⅛ - 5⅜	
24,119	7½	Do. Preferred	7½	4⅛ - 4⅜	
24,119	7½	Do. Deferred	7½	1⅝ - 1⅞	
200,000*l.*	100	Do. 6 p. c., Debs. "A" 1910 ..	100	103 -106	
250,000*l.*	100	Do. 6 p. c. Mort. Deb. B. '80, red. Feb. 1910	100	98 -101	
1,500	$1,000	Western Union 7 p. c. 1 Mort. (Bg.) Bds.	$1,000	122 -126	
1,030,000*l.*	100	Do. 6 per cent. Sterling Bonds	100	102 -106	
88,321	10	West India and Panama, Limited	10	⅝ - 1⅛	
34,563	10	Do. 6 per cent. 1st Preference	10	7 - 7½	
4,089	10	Do. 6 do. 2nd do. ..	10	5 - 5½	
		TELEPHONES.			
224,850	1	Con. Tele. & Mainten., L., Nos. to 154,165	1	1/16 - 3/16	
225,000	1	Oriental Tele. Co., Nos. 80,001 to 300,000	¼	1/16 - 3/16	
100,000	5	United Telephone Co.	5	7⅜ - 8	
20,000	5	Do. New, issued 2 p.m.	2	..	

TRAFFIC RECEIPTS.

The West India and Panama Telegraph Company, Limited. The estimated receipts for the half-month ended the 29th February, are £2,441, as compared with £3,441 in the corresponding period of 1883.

The Great Northern Telegraph Company. The receipts in February, 1884, £19,720; from 1st January to 29th February, 1884, £38,680; corresponding months, 1883, £36,458; 1882, £34,360.

The West Coast of America Telegraph Company, Limited. The gross earnings for the month ending February 29th, amounted to £4,600.

NEW PATENTS—1884.

4370. "Mandrels and dies for manufacturing lead-armoured cables." R. S. WARING. Dated March 4. (*Complete.*)

4388. "Apparatus for measuring the strength and potential of electric currents." J. WIMSHURST. Dated March 5.

4408. "Primary voltaic batteries." J. LUCAS. Dated March 5.

4428. "Clocks, more especially electric clocks." J. M. RICHARDS. (Communicated by G. B. Webb.)

4432. "Plates for secondary cells or batteries." N. C. COOKSON, J. SWINBURNE. Dated March 6.

4460. "Primary electric battery." H. BINKO. Dated March 6.

4475. "Electric piles or batteries." F. DE LALANDE, G. CHAPERON, Dated March 6. (*Complete*).

4494. "Dynamo-electric machine." W. H. BECK. (Communicated by A. J. Cote and E. F. Lesobre). Dated March 6.

4503. "Compound electric conductors." W. P. THOMPSON. (Communicated by F. L. Pope.) Dated March 7.

4548. "Appliance or band for generating electricity for therapeutic purposes." A. H. BYNG. Dated March 7.

4552. "Electric lamps or lighting apparatus." H. H. LAKE. (Communicated by F. H. Werner and L. Ochse.) Dated March 7.

4560. "System of telephonic transmission." A. M. CLARK. (Communicated by L. Maiche.) Dated March 7.

4651. "Dynamo-electric and magneto-electric machines," A. N. THORIN. Dated March 10. (*Complete.*)

4655. "Making, maintaining, and breaking connection between electric lamps and the source of electricity used." Sir W. THOMSON. Dated March 10.

4665. "Regulating electro motors and appliances for electrically controlling and regulating the speed of motors employed for driving dynamo-electric machines." C. J. BOSANQUET, W. A. TOMLINSON. Dated March 10.

4683. "Dynamo-electric machines." W. H. SCOTT, E. A. PARIS. Dated March 11.

4685. "Driving dynamo-electric machines." W. P. THOMPSON. (Communicated by J. B. Wayne and J. R. Markle.) Dated March 11. (*Complete.*)

4696. "Electrical meter." P. JOHN, J. PARSONS, M. F. PURCELL. Dated March 11.

4721. "Dynamo-electric machines." W. R. LAKE. (Communicated by C. Richter.) Dated March 11. (*Complete.*)

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1883.

2965. "Method of and apparatus for storing and retaining electric energy." F. J. CHEESBROUGH. (Communicated from abroad by C. T. Tomkins, of America.) Dated June 14. 8d. The inventor makes a battery consisting of an ordinary porous cup set into an ordinary earthen or glass battery jar, the porous cup being at least equal in length to the jar by which it is enclosed, but much less in diameter, leaving an annular space between the two. The porous cup he fills with a combination of pulverized charcoal and graphite, or gas carbon, using the charcoal as an absorbent and the graphite, or gas carbon, as a conductor of the current to and through the charcoal. He then places in the annular space between the cup and the jar a metal brush, composed of fine lead fibres, or filaments, and long enough to reach to the bottom of the jar, and in the centre of the combined charcoal and graphite he places a silver strip or rod, reaching from the top to the bottom of the cup. He then fills the intervening space between the jar and cup with an electrolytic fluid, and connects the lead or positive electrode with the negative pole of a primary battery and the negative electrode through the silver rod to the positive pole of the primary battery.

2978. "Creating a vacuum in the bulbs of incandescent electric lamps." C. H. STEARN. Dated June 15. 4d. Has for its object to provide an effectual and convenient means for producing a permanent high vacuum in the bulbs of incandescent electric lamps. According to the said invention, the inventor encloses the bulb in which the vacuum is to be created in a casing box or covering made of asbestos or other non-conductor or slow conductor of heat, which casing box or covering may or may not fit closely to the bulb. For example, it may consist of a base or platform with orifices for the tube through which the exhaustion is effected and for the conducting wires to pass through, and of a cap, cover, or box which is placed over the bulb and rests upon the said base or platform. The bulb being enclosed in the said casing box or covering, is connected to the exhausting apparatus, and when during the final exhaustion a current of electricity is passed through the filament of the lamp, the said casing box or covering retains the heat so that the bulb rapidly acquires and retains a high temperature during the said final exhaustion which enables a very high and perfect permanent vacuum to be created in the bulb.

2979. "Electric hand tool for the use of manufacturing jewellers, &c." T. H. S. HAWKER and J. W. SALAMAN. Dated June 15. 2d. Consists of a hand tool or apparatus containing or forming an electric motor, which is put into operation by a battery or other suitable generator placed at a convenient distance from the operator, and connected by insulated wires to the said electro-motor. (*Provisional only.*)

2984. "Manufacture of electric wire conductors and insulators. J. GREENWOOD. Dated June 15. 4d. The inventor pulverises a quantity of furnace slag or steam furnace and domestic ashes combined with it, and adds about one fourth of hydraulic lime and subjects them to intense heat. He then melts in a suitable vessel a quantity of tar or pitch with a small proportion of mineral or other oil and sulphur, and when sufficiently heated he adds the ground slag or ashes and hydraulic lime, and causes the whole to be thoroughly mixed by means of heated rollers or any other suitable means. When the whole is thoroughly worked into a paste it is placed in suitable moulds and submitted to a pressure varying according to the strength of material required.

2988. "Electro-motors." R. D. BOWMAN. Dated June 15. 2d. Consists in providing the ends of the electro-magnets with pole pieces of a segmental shape, in order to extend the magnetic field. (*Provisional only.*)

2994. "Electric incandescence lamps." A. M. CLARK. (Communicated from abroad by J. M. A. Gérard-Lescuyer, of Paris. Dated June 15. 6d. Consists of a pair of fine carbon pencils inclined so as to cross one another near the points, the said carbons being connected at the crossing point by traversing a hole in a small carbon disc which the carbons enter at opposite sides, so that it lies in a plane between them.

3003. "Construction of arc lamps, &c." T. H. S. HAWKER. Dated June 16. 2d. Relates chiefly to the combination of a reversible electro-motor with a polechanger actuated by a differential solenoid and with mechanism by which the carbons are made to approach or to separate; and to the regulation of the arc between two gravitating carbons by the intrusion and withdrawal of a tongue of refractory material under the influence of a differentially wound solenoid or electro-magnet. (*Provisional only.*)

3031. "Production of light by electricity, and apparatus therefor." W. P. THOMPSON. (A communication from R. J. Sheehy, of America.) Dated June 19. 6d. Consists in a method of and apparatus for maintaining the proper relative positions of the electrodes in an electric lamp.

3074. "Dynamo-electric machines." MARCEL DEPREZ. Dated June 21. 1s. Has reference chiefly to the construction of a continuous current dynamo-electric machine based on the reciprocal magnetic actions of iron upon iron, which for equal weight are much more energetic than those of iron upon copper.

3080. "Telephones." A. W. ROSE. Dated June 21. 6d. Has for its principal object to so arrange and connect the receiver and transmitter of a telephone that they form one instrument, which can be carried in the hand, so that the receiver may be placed simultaneously to the ear and the transmitter to the mouth of the operator of the instrument.

3100. "Incandescent Electric Lamps." R. HARRISON. Dated June 22. 6d. Relates to the construction of the bulbs of incandescent electric lamps, and to the preparation and means of fixing the filament and its conducting wires. In blowing the bulb, the inventor forms its neck of a flat approximately elliptical section with a slit which opens the top of the neck and extends some way down each of its narrow sides. He attaches the two ends of the carbon filament by iron wires to the longer ends of two L shaped pieces of metal, and on the parts of these L pieces, next their angles, he fixes a coating of glass by squeezing on them pieces of heated glass. He then inserts the carbon into the bulb, passing the tails of the L pieces down the two slits of the neck, so that their ends project outwardly. He then heats the neck of the bulb, and, by means of a suitable pinching tool, he closes it on the L pieces, and at the same time on a mandril held in the centre of the neck. He then draws out a tubular end to the bulb which serves for the exhaustion of the bulb afterwards.

3102. "Telephone." S. J. COXETER and H. NEHMER. Dated June 22. 2d. Consists mainly in employing the movements of the walls of one or more tubes (these movements being effected by electrical undulatory currents in conjunction with permanent or electro-magnets) as a means to set into vibration corresponding vibrations in a column of air within them, and thus reproduce speech. (*Provisional only.*)

3115. "Dynamo-electric machines." Professor G. FORBES. Dated June 22. 6d. The armature of the machine is a revolving mass of iron without coils, and the field-magnet is continuous all around the armature which it completely encloses, except that there is a central hole by which the axis passes. The magnet presents a continuous north pole to one side, and a continuous south pole to the other side of the armature, whose polarity is also continuous.

3116. "Arrangement of circuits and apparatus to be used in connection with telephonic communication." SYDNEY PITT. (Communicated from abroad by C. E. Scribner, of America. Dated June 22. 8d. This invention is an improvement upon the system of telephonic exchange described in letters patent dated the 29th November, 1879, number 4903.

3123. "Electrical apparatus and circuit connections to storage or secondary batteries, &c." W. HOCHHAUSEN. Dated June 23. 6d. The object of this invention is to provide for charging and discharging the secondary or storage batteries, and to render the secondary battery available as a means for changing the circuit connections automatically.

3126. "Application of governors or apparatus for making and breaking contact between electro-motors, &c." Sir DAVID SALOMONS. Dated June 23. 6d. The inventor arranges a ball or other suitable governor or like apparatus, actuated by the engine or driving apparatus, so that the electric current generated by an electro-motor or dynamo-machine shall not be transmitted through an accumulator (or series of accumulators) until the engine or driving apparatus has attained a requisite or determined speed at which the electric current is to be allowed to pass to the accumulators (or elsewhere) to absorb any excess of the electric current not required for immediate use, and when at rest may either simply break the circuit or shunt it to some other circuit.

3127. "Preparation and manufacture of a compound from vegetable materials suitable for electro non-conductors and insulators, &c." E. C. T. BLAKE. Dated June 23. 4d. This invention relates to improvements in the preparation and manufacture of an improved compound from vegetable materials suitable for being used for electro non-conductors and insulators, such compound being applicable to other useful purposes.

3131. "Apparatus for telegraphic and telephonic communication." O. SCHAFFLER. Dated June 23. 8d. Has for its object to call, from among the stations connected in a partial circuit, the one only for which the message is intended, without alarming the others, and thus to deprive them of the opportunity of disturbing the calling and the correspondence when once begun, and of reading the latter, or noting it in any other way.

3167. "Incandescent electric lamps, &c." H. J. HADDAN. (Communicated from abroad by R. H. S. Thompson, of America.) Dated June 26. 6d. Consists in an improved mode of and means whereby the amount of light emitted by the incandescent loop or filament may be increased or diminished without changing the colour or degree of incandescence of the same, and whereby the amount of electricity used will vary directly as the illuminating power of the lamp increases or diminishes.

3182. "Galvanic batteries." J. R. ROGERS and J. W. ROGERS. Dated June 27. 2d. Relates to the use of two porous pots, parts of which are made impervious to the solutions, one is of a less diameter than the other, and the smaller one is placed within the larger. In the inner porous cell is placed a carbon plate or block together with a mixture of graphite and peroxide of manganese, which mixture is to be saturated with nitric acid; and in the larger cell is placed a carbon plate or block, the intervening space being filled with a mixture of graphite and peroxide of manganese, this mixture is to be saturated with some acid other than nitric, or with a solution of some soluble salt other than that of a nitrate. The two carbon plates or blocks are to be connected together by means of some good conductor of electricity, this combination forms the negative element which is put into a cell containing some acid other than a nitric, or in a solution of some soluble salt other than that of a nitrate, with a rod or cylinder of zinc as the positive element. The cell which contains the nitric acid is to be covered over on top and connected by means of a bent tube with the inside of either of the other cells.

3185. "Telephonic transmitters." C. F. POLLAK. Dated June 27. 2d. Consists of an improvement on any telephonic transmitters in which the platinum and the carbon are fixed in a manner similar to the so-called "Blake's system." *(Provisional only.)*

3211. "Manufacture or treatment of porous pots and porous plates for galvanic batteries." T. COAD. Dated June 28. 2d. Relates to the manufacture or treatment of porous pots and porous plates used in galvanic batteries, whereby the said pots and plates are rendered more homogeneous and have greater conductivity, so as to prevent excess of endosmose, and thereby increase their duration, and also the electromotive force of the batteries in which they are used. In carrying out the invention, the inventor takes ordinary porous pots or plates and thoroughly saturates the same with a suitable carbonaceous fluid, such as a solution of vinegar and sugar. When dry the articles are placed in a vessel and surrounded or covered with any suitable carbonaceous material, such as powdered blacklead; the vessel is then closed, and heat is applied until the porous pots or plates are carbonized.

3218. "Apparatus for mounting or supporting electric lamps." W. R. LAKE. (Communicated from abroad by J. Languereau of Paris.) Dated June 28. 6d. Relates to improvements in apparatus for mounting or supporting electric lamps, and it consists essentially in the adaptation of incandescent lamps to the top of a tabular support, having the form of a candle, this support being arranged in such a manner as to allow of the easy application of the lamp, the admission of the current in such a manner as to conceal the conducting wires through which it passes, and the rapid erection and removal of the said lamps.

3219. "Distribution of electric currents." H. E. NEWTON. (Communicated from abroad by A. I. Gravier, of Russia.) Dated June 28. 6d. The object of the present invention is to charge a network of distribution with currents emitted under high pressure and transformed into useful currents of low pressure through the expansion of the electricity. *(Provisional only.)*

3223. "Dynamo-electric, magneto-electric, and similar machines." L. F. LAMKIN. Dated June 29. 6d. Consists in providing means whereby the positions of the brushes may be changed relatively to each other, either by hand or by an automatic device in such a manner that either the maximum or any desired lower difference of potential may be obtained.

3233. "Electric arc lamps." C. WUEST. Dated June 29. 6d. Relates to electric arc lamps, the carbons of which are fed by means of rollers, whereby their resistance is made independent of their length.

3244. "Automatic electric signalling apparatus for railways." H. J. HADDAN. (Communicated from abroad by H. C. Reher, of Hamburg.) Dated June 30. 4d. In this electro-mechanical system automatic current closers or contact devices are placed at the end of the sections of the railway, which contact devices are suitably connected with the rails, and operate the signals along the railway line through the locomotive wheels.

DISCLAIMER.

539* (1883). "Tram, rail, and road cars, &c., and machinery for driving same by electricity." M. R. WARD. Filed December 22, 1883.

CORRESPONDENCE.

A Non-sparking Key.

In your issue for the 22nd February Mr. Jamieson claims priority in the invention of our non-sparking key recently exhibited by us at the Physical Society, because he employed in 1883 the key which is illustrated in his letter. He clearly, therefore, is not aware that his key may be found fully described, with various improvements, in one of our patent specifications for 1881, and that an embryo key, such as he used in 1883, was, with many modifications, such as replacing the coils by carbon, &c., experimented on by us for some months in 1882, and finally abandoned by us in 1883 in favour of the key which we recently exhibited, and which is the outcome of the method described in our 1881 patent for avoiding a spark by gradually introducing resistance on breaking circuit.

The conditions we find necessary for entirely preventing any spark, and for ensuring the successful working of a non-sparking key, and which conditions are completely fulfilled in our latest form of key, but which were only partially fulfilled in our 1883 types, and still less perfectly in that one of our 1882 types, which is the one described now by Mr. Jamieson, are :—

1. The addition of resistance to the circuit must follow a special law, which requires the employment of a large number of coils of rapidly increasing resistance; hence the special form our key has ultimately acquired. See the ELECTRICAL REVIEW for February 8th.

2. The coils must be introduced at a definite rate, independently of the control, or motion of the hand, of the manipulator; hence the employment of our trigger arrangement.

3. It must be impossible to leave the key in an intermediate position, otherwise some of the coils will be fused.

Ayrton and Perry.

Telpher House, *March 12th*, 1884.
73, Great Eastern Street, E.C.

Spiral Telephone Wire.

As an extensive, but totally unauthorised use has been made of the National Telephone Company's name by the Spiral Wire Syndicate, founded on the facts that the company had agreed to give the wire (as they like to give all new things) a trial, and that their manager at Dundee had been induced to certify that so far as he had observed the speaking by the spiral wire was clearer than by the older ones, I would ask space to detail the results of tests applied by me at Dundee, on March 11th, to one spiral wire and three ordinary ones, each 4 miles

197 yards long, extending from the Company's Dundee Central Exchange to their Broughty Ferry Exchange.

These tests proved conclusively that in no sense whatever does the spiral wire possess any superiority over the ordinary ones.

The overhearing to and from the spiral wire was as pronounced as that between any of the others.

The speaking was good on all the wires, and the ticking of a watch was audible on all. But one of the older wires showed a decided advantage in respect to loudness of transmission over the spiral, while the other two were at least equal to it.

The conductivity and insulation of the wires were as follows :—

			Per mile.
No. 1.	Conductor resistance, 380 ohms.	Insulation,	360,000 ohms
No. 2.	" " 375 "	"	36,000 "
No. 3.	" " 380 "	"	110,000 "
No. 4.	" " 251 "	"	92,000 "

Nos. 1, 2, and 3 were each composed partly of No. 18 silicium bronze, No. 20 phosphor bronze, and No. 14 galvanised iron. No. 4 was the spiral No. 13 steel wire, the only one the company have erected. The low and varied insulation is accounted for by the fact that the wires run along a densely-wooded road, and touch the trees (which are not allowed to be trimmed) here and there. But one of the old wires (No. 2) suffered more in this way than the spiral, and yet spoke just as well.

The speaking tests were conducted by three expert observers, listening at Dundee, who were kept ignorant of the wire upon which they were pronouncing judgment. The speaker, who was stationed at Broughty Ferry, was the same throughout, and the same instruments were used. The wires were tested in pairs, and the mode of procedure was for the speaker to count from one to twenty without varying his voice or distance from the transmitter, and without knowing the wire he was speaking on. At the word "ten," a switch at Dundee suddenly changed the wires without the knowledge of the observers. So the numerals 1 to 10 were heard on one wire, and 11 to 20 on another, an arrangement which enabled very slight variations in loudness between the first and second portions to be noticed. The results were as follows :—

All three observers agreed that No. 1 spoke better than No. 4.

All agreed that Nos. 2 and 4 were practically alike. Two thought No. 3 was slightly better than No. 4, while the third thought the reverse was the case. The difference, if any, was, however, of no practical importance.

All tests were repeated, some several times, without varying the results in the least.

One of the observers was Mr. Lumley, who satisfied himself that his original tests must have been erroneous. He appears to have tried the spiral against only one of the older lines, and the last results clearly indicate that there must have been a serious fault on this wire, or in some of its connections, at the time.

In justice to Mr. Lumley, it should be known that he gave the certificate on the assurance that it was required for the private information of the Syndicate, and was not intended for publication. It was granted without the knowledge of any of the company's other officials.

A. R. Bennett,
Engineer for Scotland and Ireland to the National Telephone Company, Limited.

Glasgow, *March 12th.*

[We have great pleasure in publishing Mr. Bennett's communication, for it bears out entirely what we have already said respecting this so-called invention. A more senseless and unintelligible prospectus than that issued by the "Spiral Wire Syndicate" it is difficult to conceive. Yet we notice in the *Postal, Telegraphic, and Telephonic Gazette* (we do not usually name our contemporaries when criticising their contents, but in this case we feel bound so to do), a statement, which does not redound to its credit, and which is not likely to increase the reputation of its Editors as scientists. The paragraph reads as follows :—

"THE BRITISH SPIRAL TELEPHONE WIRE SYNDICATE.—The lists for this company close to-day for London, and to-morrow for the country. We consider this investment a thoroughly sound one, which holds out exceptional promise of high dividends, and we can safely recommend the enterprise to our readers. . . . . Contracts have already been entered into with the chairman of the National Telephone Company, London, whereby the wires now in their service between Dundee and Broughty Ferry are to be removed, and the spiral wire substituted therefor. Arrangements have already been made for the supply of all the spiral wire which can be manufactured by the syndicate during the next two months, and the syndicate will therefore take over a concern in thorough going order and earning considerable profits at the outset. The high estimation in which the spiral wire is held in the United States, and the successful tests made in this country, make it a matter of absolute certainty that the wire will be largely adopted by the telephone companies throughout the world. It is difficult to realise what that means, but even those little acquainted with that modern giant, the telephone, must know how great a future is before the telephone, and how many thousands of miles will be required both for replacing old services and for erecting new lines. We have no doubt the syndicate will meet with great success."

The above absurd statements when compared with Mr. Bennett's letter need no further comment. That gentleman has our best thanks (and we are sure that we may also add those of the whole electrical profession) for showing how much reliance may be placed on the tests hitherto made, or *said* to have been made, on the spiral telephone wire.—EDS. ELEC. REV.]

A Comment.

I cannot refrain from expressing my astonishment that you should have published in the REVIEW of 8th inst., a communication in which expressions not tolerated among gentlemen are used towards a correspondent—myself. Silence is my reply to the writer thereof.

W. C. Barney.

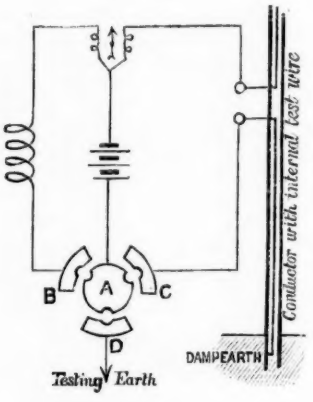
March 11th, 1884.

[If Mr. Barney alludes to the letter which immediately followed his own in our last week's issue, we cannot see anything there expressed which calls for any comment. Some correspondents may object to being corrected by another, but we cannot possibly exclude communications in which we can see no offensiveness. Certainly, in the letter to which reference is made the remarks may be thought severe, but severity is oftentimes necessary, and should therefore be taken in good part.—EDS. ELEC. REV.]

Testing Lightning Conductors.

In the interesting communication presented to your readers from the report of the French Posts and Telegraph Department, the subject of testing lightning conductors is again brought forward, and as it is dealt with somewhat upon the lines advocated by me, I should be glad of the opinions of other electricians—yourselves included—as to the "margin" of resistance to be allowed above which a conductor should be condemned. It will be remembered that Messrs. Jamieson and Munro advocate 1 ohm only. For myself, whilst knowing that some good conductors test up to that high standard, I have been led to lay down 15 ohms as the more practical resistance, and now we have the French Minister of Posts and Telegraphs recommending the still higher figure of 25 ohms. As Mr. W. H. Preece, F.R.S., made the subject of lightning conductors his "hobby," prior to the introduction of telephones and electric light, perhaps out of regard for his old love he will favour your readers with his opinion as to this question of the amount of resistance to be allowed as the safety mark up to which they may be passed.

The differential galvanometer was the first form of detector I used for testing conductors, and it had a fixed resistance of a few ohms inserted on one of the coils. By a slight alteration of the sketch which accompanied my letter in your issue of 9th February, the detector, with sealed battery attached, would be equally suitable for testing, thus :—



After seeing that the instrument was in good working order, by inserting a plug between $\frac{A}{B}$ and $\frac{A}{C}$ respectively, a metallic test of the conductor could be taken by inserting plugs at $\frac{A}{B-C}$, and of the earth of conductor by plugs at $\frac{A}{B-D}$.

In reviewing Spang's work on conductors, your American contemporary, *Science*, says :—"The inauguration of a proper system of testing lightning conductors would certainly reveal some astonishing facts in regard to the efficiency of rods." When are we likely to have a recognised system for England ?

Samuel Vyle.

March 10th, 1884.

A Telephonograph.

The following experiment may perhaps seem interesting to some of the readers of the TELEGRAPHIC JOURNAL.

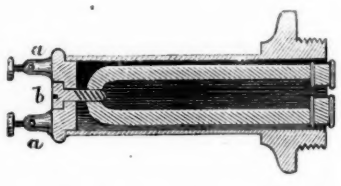
An Ader microphone (Crossley or Gower will probably do as well) is put in circuit with three Bunsen cells, and the primary of a small induction coil, the secondary of which is joined to a horse-shoe telephone of the Siemens and Halske pattern. Now, if somebody loudly speaks, sings, or whistles close to the wooden diaphragm of the microphone, the telephone will reproduce the words or melodies so loud, that they may be heard through a whole room. To get the sounds at their maximum intensity, the telephone must be provided with a large cone of paper or tin.

It occurred to me, that it must be possible for the telephone to write down such intense vibrations on the tin foil of a phonograph. Such a telephonograph has been mentioned already by Edison (*Engineer*, 1878, vol. 46, p. 415), but as, so far as I know, no microphones with multiple contacts necessary for getting up such strong telephonic currents existed then, I doubt whether he ever successfully made such an instrument.

For trying the experiment I made the apparatus sketched in the accompanying figure. It consists of a brass tube, into which is fitted a horseshoe magnet, exactly like that in a Siemens telephone, mounted with two iron cores, which are wound with insulated wire. The ends of this wire are connected with the binding screws, *a a*, while *b* is a steel adjusting screw, by turning which the magnet glides farther into the brass tube, or the reverse.

I now took a phonograph, and turned out the hole, into which commonly the conical wooden mouthpiece is screwed, so that the tube with the magnet could be screwed into it. By turning the screw, *b*, the iron spools were brought as near to the vibrating disc of the phonograph as was possible, without actually touching it.

The ordinary adjustments were now made ; care was taken that the stilus touched the tinfoil exactly over the middle of the spiral grove of the drum, and



that it pressed neither too deeply nor too loosely into the foil. The binding screws, *a a*, were connected with a double wire, leading to another room, where it ended in the secondary of an induction coil. In the primary was placed the Ader microphone and the three-Bunsen battery, as told before. Now, if somebody spoke or sung loudly, close to the diaphragm of the microphone, the phonograph being turned in the meantime, the impressions of the vibrations were clearly visible on the tinfoil. The disc-holder was then turned away, and the cylinder screwed back, after which the disc-holder was clapped into its former position, so that the stilus again touched the tinfoil at the same places where the impressions were made. The cylinder being turned, the words and melodies spoken and sung before the microphone were clearly heard, although the sounds were rather feeble. The best results were got from a cornet-â-piston, of which the opening was held at a distance of some 10 centimetres from the vibrating plate of the microphone.

The experiment could, no doubt, be made with better success, if, before reproducing the sounds, the tube with the magnet were screwed out of the disc-holder. A cone of paper or tin, for re-enforcing the sounds, could be put into the opening then, just as is done when working an ordinary phonograph. But there is one objection to this : as soon as the magnet is removed, the iron disc, being no longer attracted, thrusts the stilus deeper into the tinfoil. This makes it necessary to move the disc-holder somewhat away from the cylinder, along a straight path, perpendicular to the axis of the drum. With the instrument I used this was impossible, as the disc-holder described an arc around a vertical axis, instead of a straight line, when it was moved away from the cylinder ; by which it followed, that the stilus no longer touched the impressions in the same manner as before.

If anybody in possession of a clock-work phonograph, in which the disc-holder can be moved along a straight line, perpendicular to the axis of the drum, should find it worth his while to repeat my experiments, I make no doubt he will get nearly the same results with the telephonograph as formerly were got from the ordinary phonograph.

I need scarcely say I don't see any practical results likely to spring from the telephonograph ; I gave the above only as a lecture experiment.

If using a clock-work phonograph, the instrument may also be started and stopped from the transmitting station by means of an electro-magnet working a brake.

T. W. Giltay.

Delft, *March 10th*, 1884.

TO CORRESPONDENTS.—We have lately had several letters addressed to us for insertion in our columns, but as the writers had omitted to subscribe their names and addresses, we had no alternative but to adopt our usual measures in the matter of anonymous contributions.—[EDS. ELEC. REV.]